

Disubstituted Acetylenes Bearing Heteroaromatic and Heterobicyclic Groups Having Retinoid Like Activity

⁵SPR This is a continuation-in-part of pending U.S. Application (serial
⁶(number) 07/246,037 filed (September) 15, 1988, *now abandoned*

SULLY: Background

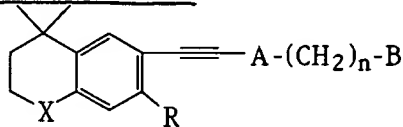
9 This invention relates to novel compounds having retinoid-like
10 activity. More specifically, the invention relates to compounds having
11 an ethynylheteroaromatic acid portion and a second portion which is a
12 tetrahydroquinolinyl, thiocromanyl, or chromanyl group. The acid
13 function may also be converted to an alcohol, aldehyde or ketone or
14 derivatives thereof, or may be reduced to -CH₃.

Ci 16 Related Art

17. β Carboxylic acid derivatives useful for inhibiting the degeneration
18 of cartilage of the general formula
19 4-(2-(4,4-dimethyl-6-X)-2-methylvinyl)benzoic acid where X is
20 tetrahydroquinolinyl, chromanyl or thiochromanyl are disclosed in
21 European Patent Application 0133795 published January 9, 1985. See
22 also European Patent Application 176034A published April 2, 1986
23 where tetrahydronaphthalene compounds having an ethynylbenzoic
24 acid group are disclosed.

CL²/₂ Summary of the Invention

9 This invention covers compounds of formula I



30 wherein X is S, O, or NR' where R' is hydrogen or lower alkyl; R is hy-

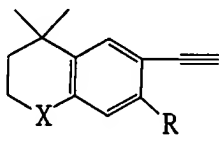
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¹ drogen or lower alkyl; A is pyridinyl, thienyl, furyl, pyridazinyl,
² pyrimidinyl or pyrazinyl; n is 0-2; and B is H, -COOH or a
³ pharmaceutically acceptable salt, ester or amide thereof, ¹³-CH₂OH or an
⁴ ether or ester derivative, or -CHO or an acetal derivative, or ¹³-COR₁ or a
⁵ ketal derivative where R₁ is ¹³-(CH₂)_mCH₃ where m is 0-4.

⁶ ρ In a second aspect, this invention relates to the use of the
⁷ compounds of formula I for treating dermatoses, such as acne, Darier's
⁸ disease, psoriasis, ichthyosis, eczema, atopic dermatitis and epithelial
⁹ cancers. These compounds are also useful in the treatment of arthritic
¹⁰ diseases and other immunological disorders (e.g., lupus
¹¹ erythematosus), in promoting wound healing, in treating dry eye
¹² syndrome and in reversing the effects of sun damage to skin.

¹³ This invention also relates to a pharmaceutical formulation
¹⁴ comprising a compound of formula I in admixture with a
¹⁵ pharmaceutically acceptable excipient.

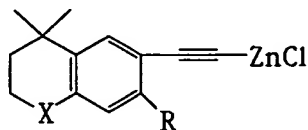
¹⁶ In another aspect, this invention relates to the process for
¹⁷ making a compound of formula I which process comprises reacting a
¹⁸ compound of formula II with a compound of formula III in the
¹⁹ presence of cuprous iodide and Pd(PQ₃)₂Cl₂ or a similar complex
²⁰ where the two formulas are represented by graphics II and III



III

²⁴ PS where X' is a halogen, preferably I; n and A are the same as defined
²⁵ above; and B is H, or a protected acid, alcohol, aldehyde or ketone,
²⁶ giving the corresponding compound of formula I; or to the process of
²⁷ making a compound of formula I which consists of reacting a zinc salt
²⁸ of formula IV with a compound of formula III in the presence of
²⁹ Pd(PQ₃)₄ (Q is phenyl) or a similar complex,

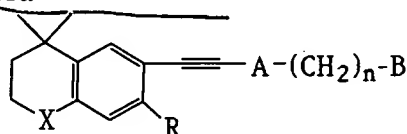
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IV

PS giving the corresponding compound of formula I; or homologating a compound of the formula

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PS where n is 0-1 to give an acid of formula I; or

- PI
- converting an acid of formula I to a salt; or
 - forming an acid addition salt;
 - converting an acid of formula I to an ester; or
 - converting an acid of formula I to an amide; or
 - reducing an acid of formula I to an alcohol or aldehyde; or
 - converting an alcohol of formula I to an ether or ester; or
 - oxidizing an alcohol of formula I to an aldehyde; or
 - converting an aldehyde of formula I to an acetal; or
 - converting a ketone of formula I to a ketal.

CL₂ General Embodiments

CL₁₉ Definitions

19 The term "ester" as used here refers to and covers any compound falling within the definition of that term as classically used in organic chemistry. Where A is -COOH, this term covers the products derived from treatment of this function with alcohols. Where the ester is derived from compounds where A is -CH₂OH, this term covers compounds of the formula -CH₂OOCR where R is any substituted or unsubstituted aliphatic, aromatic or aliphatic-aromatic group.

Preferred esters are derived from the saturated aliphatic alcohols or acids of ten or fewer carbon atoms or the cyclic or saturated

1 aliphatic cyclic alcohols and acids of 5 to 10 carbon atoms. Particularly
2 preferred aliphatic esters are those derived from lower alkyl acids and
3 alcohols. Here, and where ever else used, lower alkyl means having
4 1-6 carbon atoms. Also preferred are the phenyl or lower alkylphenyl
5 ¹⁴esters.

6 Amide has the meaning classically accorded that term in organic
7 chemistry. In this instance it includes the unsubstituted amides and
8 all aliphatic and aromatic mono- and di-substituted amides. Preferred
9 amides are the mono- and di-substituted amides derived from the
10 saturated aliphatic radicals of ten or fewer carbon atoms or the cyclic
11 or saturated aliphatic-cyclic radicals of 5 to 10 carbon atoms.
12 Particularly preferred amides are those derived from lower alkyl
13 amines. Also preferred are mono- and di-substituted amides derived
14 from the phenyl or lower alkylphenyl amines. Unsubstituted amides
15 are also preferred.

16 Acetals and ketals includes the radicals of the formula ¹³-CK where
17 K is ¹³(-OR)₂. Here, R is lower alkyl. Also, K may be ¹³-OR₁O-¹³ where R₁ is
18 lower alkyl of 2-5 carbon atoms, straight chain or branched.

✓ 19 A pharmaceutically acceptable salt may be prepared for any
20 compound of this invention having a functionality capable of forming
21 such salt, for example an acid or an amine functionality. A
22 pharmaceutically acceptable salt may be any salt which retains the
23 activity of the parent compound and does not impart any deleterious
24 or untoward effect on the subject to which it is administered and in the
25 context in which it is administered.

26 Such a salt may be derived from any organic or inorganic acid or
27 base. The salt may be a mono or polyvalent ion. Of particular interest
28 where the acid function is concerned are the inorganic ions, sodium,
29 potassium, calcium, and magnesium. Organic amine salts may be made
30 with amines, particularly ammonium salts such as mono-, di- and
31 trialkyl amines or ethanol amines. Salts may also be formed with

1 caffeine, tromethamine and similar molecules. Where there is a
2 nitrogen sufficiently basic as to be capable of forming acid addition
3 salts, such may be formed with any inorganic or organic acids or
4 alkylating agent such as methyl iodide. Preferred salts are those
5 formed with inorganic acids such as hydrochloric acid, sulfuric acid or
6 phosphoric acid. Any of a number of simple organic acids such as a
7 mono-, di- or tri-acid may also be used.

8 The preferred compounds of this invention are those where the
9 ethynyl group and the B group are attached to the 2 and 5 positions
10 respectively of a pyridine ring (the 6 and 3 positions in the nicotinic
11 acid nomenclature being equivalent to the 2/5 designation in the
12 pyridine nomenclature) or the 5 and 2 positions respectively of a
13 thiophene group respectively; n is 0; and B is -COOH , an alkali metal
14 salt or organic amine salt, or a lower alkyl ester, or $\text{-CH}_2\text{OH}$ and the
15 lower alkyl esters and ethers thereof, or -CHO and acetal derivatives
16 thereof.

17 The most preferred compounds are:

18 PO ethyl 6-(2-(4,4-dimethylthiochroman-6-yl)ethynyl)nicotinate;
19 6-(2-(4,4-dimethylthiochroman-6-yl)ethynyl)nicotinic acid;
20 6-(2-(4,4-dimethylchroman-6-yl)ethynyl)nicotinic acid;
21 ethyl 6-(2-(4,4-dimethylchroman-6-yl)ethynyl)nicotinate;
22 ethyl 6-(2-(4,4,7-trimethylthiochroman-6-yl)-ethynyl)nicotinate;
23 L ethyl 6-(2-(4,4-dimethyl-1,2,3,4-tetrahydroquinolin-6-yl)-
24 ethynyl)nicotinate;

25 PO ethyl 5-(2-(4,4-dimethylthiochroman-6-yl)ethynyl)-
26 thiophene-2-carboxylate.

27 PO 6-(2-(4,4-dimethylthiochroman-6-yl)-ethynyl)-3-
28 pyridylmethanol; and

29 PO 2-(2-(4,4-dimethylthiochroman-6-yl)-ethynyl)-5-
30 pyridinecarboxaldehyde.

31 P The compounds of this invention may be administered

1 systemically or topically, depending on such considerations as the
2 condition to be treated, need for site-specific treatment, quantity of
3 drug to be administered, and similar considerations.

4 In the treatment of dermatoses, it will generally be preferred to
5 administer the drug topically, though in certain cases such as
6 treatment of severe cystic acne, oral administration may also be used.
7 Any common topical formulation such as a solution, suspension, gel,
8 ointment, or salve and the like may be used. Preparation of such
9 topical formulations are well described in the art of pharmaceutical
3 10 formulations as exemplified, for example, Remington's Pharmaceutical
11 Science, Edition 17, Mack Publishing Company, Easton, Pennsylvania.
12 For topical application, these compounds could also be administered as
13 a powder or spray, particularly in aerosol form.

14 If the drug is to be administered systemically, it may be
15 confected as a powder, pill, tablet or the like, or as a syrup or elixir for
16 oral administration. For intravenous or intraperitoneal administration,
17 the compound will be prepared as a solution or suspension capable of
18 being administered by injection. In certain cases, it may be useful to
19 formulate these compounds in suppository form or as an extended
20 release formulation for deposit under the skin or intermuscular
21 injection.

22 Other medicaments can be added to such topical formulation for
23 such secondary purposes as treating skin dryness, providing protection
24 against light; other medications for treating dermatoses, preventing
25 infection, reducing irritation, inflammation and the like.

26 Treatment of dermatoses or any other indications known or
27 discovered to be susceptible to treatment by retinoic acid-like
28 compounds will be effected by administration of the therapeutically
29 effective dose of one or more compounds of the instant invention. A
30 therapeutic concentration will be that concentration which effects
31 reduction of the particular condition, or retards its expansion. In

1 certain instances, the drug potentially could be used in a prophylactic
2 manner to prevent onset of a particular condition. A given therapeutic
3 concentration will vary from condition to condition and in certain
4 instances may vary with the severity of the condition being treated
5 and the patient's susceptibility to treatment. Accordingly, a given
6 therapeutic concentration will be best determined at the time and
7 place through routine experimentation. However, it is anticipated that
8 in the treatment of, for example, acne, or other such dermatoses, that a
9 formulation containing between 0.001 and 5 percent by weight,
10 preferably about 0.01 to 1%, will usually constitute a therapeutically
11 effective concentration. If administered systemically, an amount
12 between 0.01 and 100 mg per kg body weight per day, but preferably
13 about 0.1 to 10 mg/kg, will effect a therapeutic result in most
14 instances.

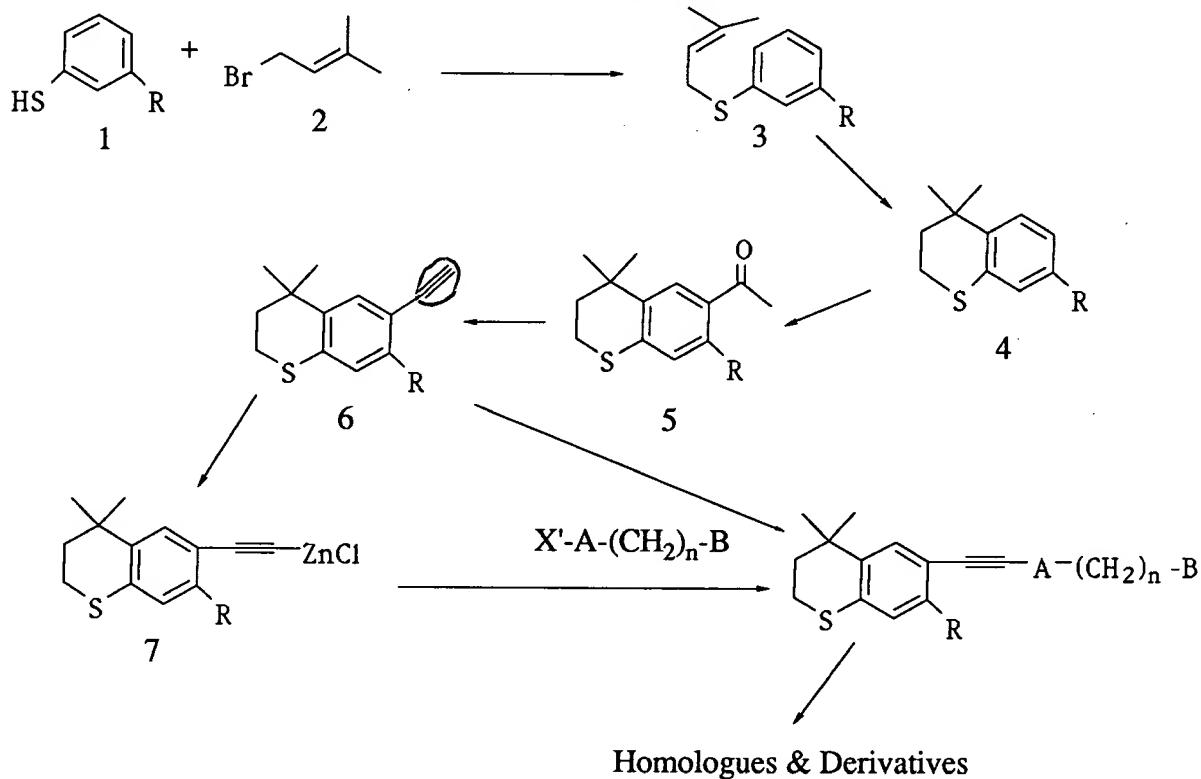
15 The retinoic acid like activity of these compounds was confirmed
16 through the classic measure of retinoic acid activity involving the
17 effects of retinoic acid on ornithine decarboxylase. The original work
18 on the correlation between retinoic acid and decrease in cell
19 proliferation was done by Verma & Boutwell, Cancer Research, 1977,
20 37, 2196-2201. That reference discloses that ornithine decarboxylase
21 (ODC) activity increased precedent to polyamine biosynthesis. It has
22 been established elsewhere that increases in polyamine synthesis can
23 be correlated or associated with cellular proliferation. Thus, if ODC
24 activity could be inhibited, cell hyperproliferation could be modulated.
25 Although all causes for ODC activity increase are unknown, it is known
26 that 12-O-tetradecanoyl-
27 phorbol-13-acetate (TPA) induces ODC activity. Retinoic acid inhibits
28 this induction of ODC activity by TPA. The compounds of this invention
29 also inhibit TPA induction of ODC as demonstrated by an assay
30 essentially following the procedure set out in Cancer Res.: 1662-1670,
31 1975.

CL^y Specific Embodiments

3 The compounds of this invention can be made by a number of
4 different synthetic chemical pathways. To illustrate this invention,
5 there is here outlined a series of steps which have been proven to
6 provide the compounds of formula I when such synthesis is followed in
7 fact and in spirit. The synthetic chemist will readily appreciate that
8 the conditions set out here are specific embodiments which can be
9 generalized to any and all of the compounds represented by formula I.

¹⁰ 13 Compounds of formula I where X is -S- are prepared as per
¹¹ Reaction Scheme I.

Reaction Scheme I

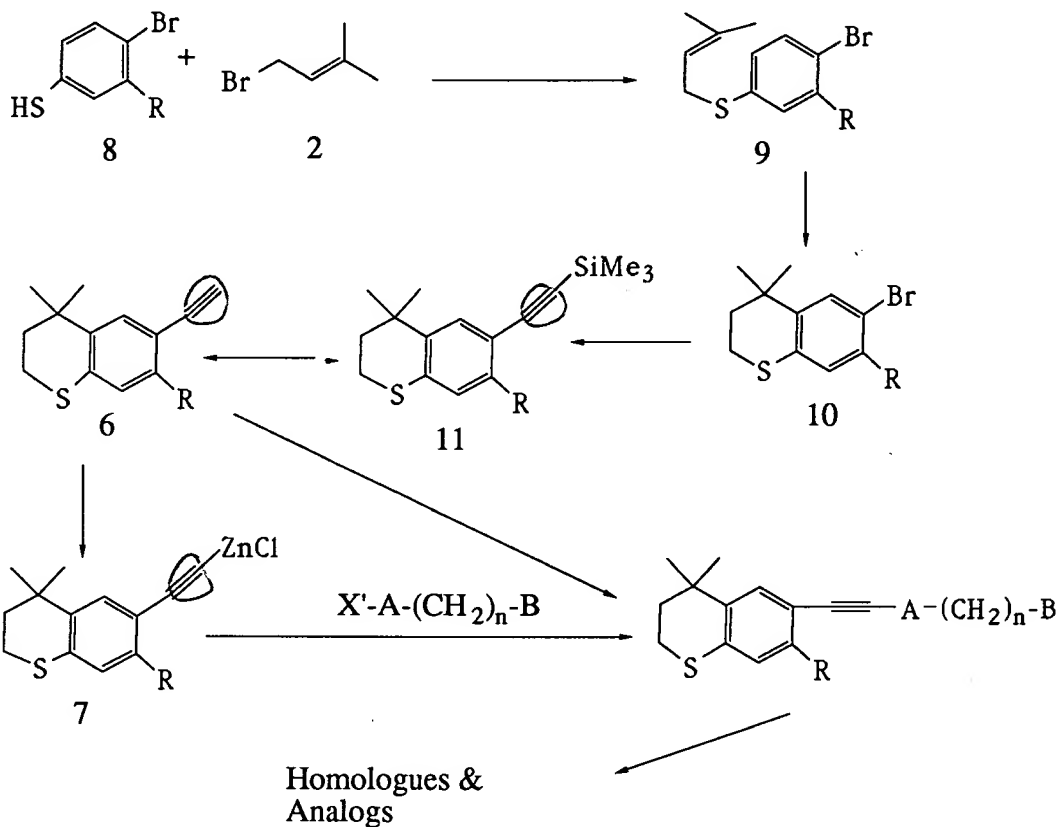


Here, R is hydrogen or a lower alkyl group, A is defined above, n is 0-2

¹ and B is H, or a protected acid, alcohol, aldehyde or ketone. X' is Cl, Br
² or I when n is 0 but preferably is Br or I when n is 1 or 2.

³ ρ Alternatively, compounds of formula I where X is -S- are
⁴ prepared as per Reaction Scheme II

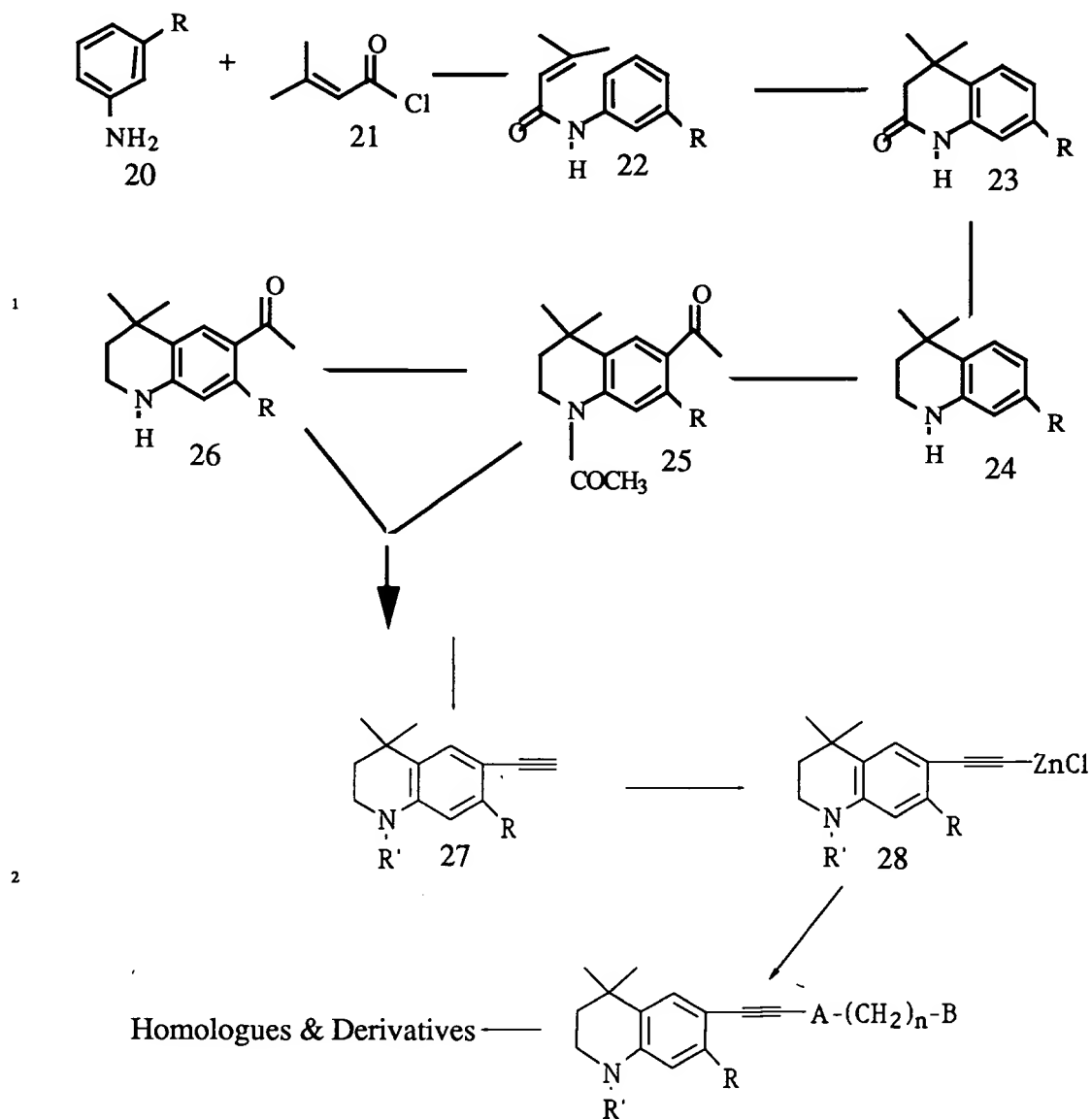
Reaction Scheme II



⁵ ρ The definitions of R, n, A, B and X' are the same here as in Reaction
⁹ Scheme I.

¹⁰ ρ Compounds of formula I where X is oxygen are prepared as per
¹¹ Reaction Scheme III.

Reaction Scheme III



3 The definitions of R', n, A, B and X' are the same here as in Scheme I.

5 Alternatively, the sequence of steps outlined in Reaction Scheme

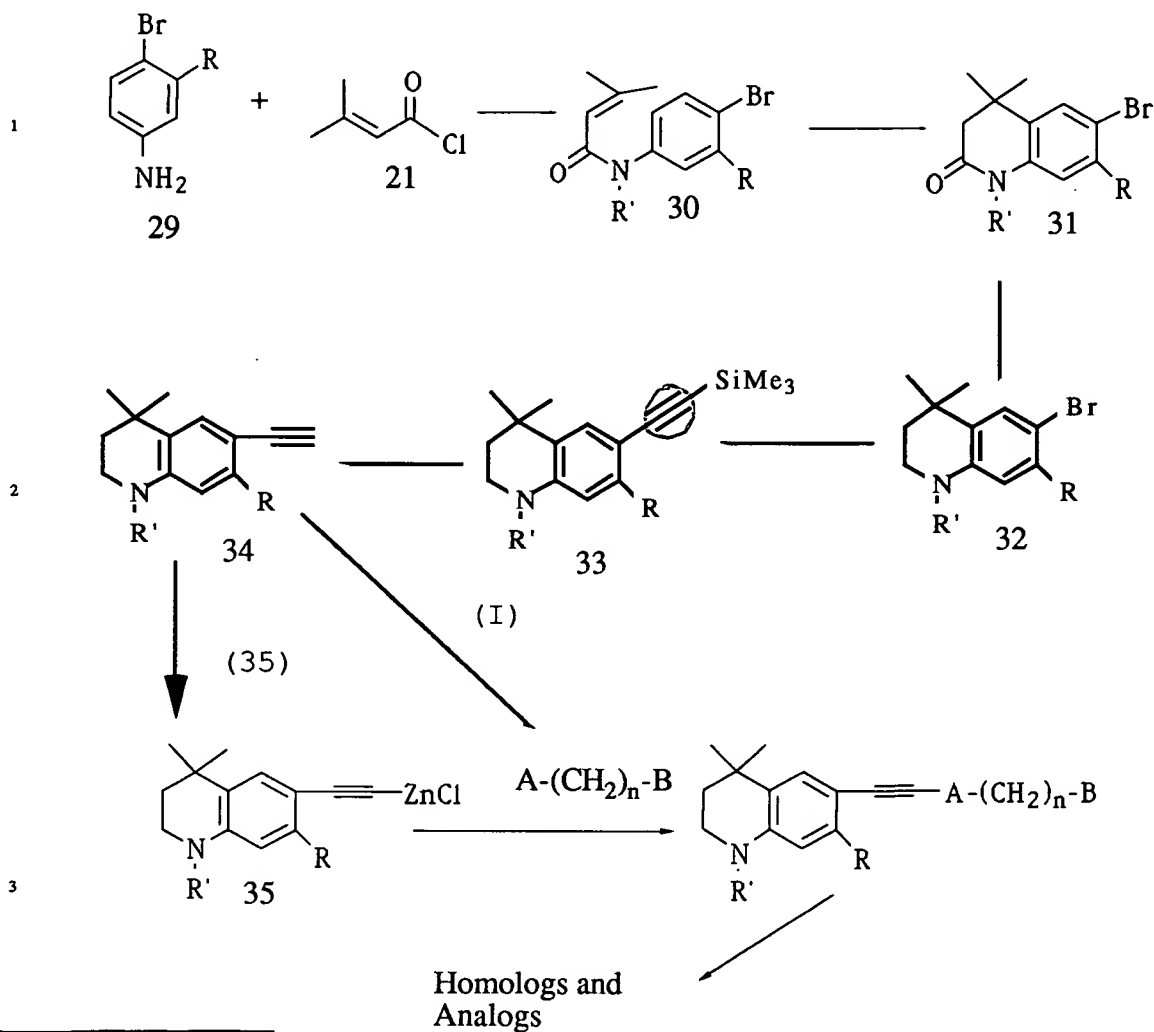
6 V will serve to make such compounds where X is N-R' and R' is H or

7 lower alkyl.

Reaction Scheme V

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4 A general description for making each of the compounds recited
5 in the foregoing Reaction Schemes follows.

6 In Reaction Scheme I, the following generalized reaction
7 conditions are applicable. The thiophenol of formula 1 is first treated
8 with approximately an equimolar amount of a strong base such as an
9 alkali metal hydroxide, preferably sodium hydroxide, in acetone at
10 reflux. Refluxing is carried out for between 1 and 4 hours, preferably
11 2.5 hours, after which the solution is treated with an equimolar
12 amount of formula 2, 1-bromo-3-methyl- 2-butene (Aldrich),
13 dissolved in acetone. Refluxing is continued for about 2 days after

1 which the solution is stirred for another 24 hours at about room
2 temperature effecting formation of formula 3. It is isolated by
3 conventional means.

4 ρ Ring closure is effected by treating the sulfide (compound 3),
5 whose formation is described above, with phosphorous pentoxide in
6 the presence of phosphoric acid under an inert atmosphere to give the
7 thiochroman of formula 4. The sulfide is first dissolved in an inert
8 solvent such as benzene, toluene, or the like, and then treated with a
9 small excess of phosphorous pentoxide along with concentrated
10 phosphoric acid. The solution is heated at reflux with stirring under an
11 inert gas such as argon or nitrogen for up to 24 hours. The product is
12 then recovered and purified by conventional means.

13 The ketone of formula 5 is obtained by treating the thiochroman
14 with acetyl chloride in the presence of aluminum chloride. A
15 suspension of the aluminum chloride in a polar inert solvent is
16 prepared under an inert atmosphere and at reduced temperature, i.e.,
31 17 -10 to 10°C. The inert atmosphere may be argon or nitrogen,
18 preferably argon. The reaction is conveniently carried out in a solvent
19 such as methylene chloride. To the aluminum chloride suspension is
20 added the thiochroman and acetyl chloride via a dropping funnel or
21 similar device. About a 5% molar excess of acetyl chloride and 10%
22 molar excess of aluminum chloride, relative to the thiochroman
23 material, is used. The reaction is effected with agitation (stirring) over
14 24 0.5-4 hours at a temperature between 10-50°C. Preferably the
25 reaction is effected in about 2 hours at room temperature. Then the
26 reaction is quenched with water and/or ice, the product extracted and
27 further purified by distillation or some other appropriate means.

28 The acetylenic function of formula 6 is introduced by means of
29 lithium diisopropylamide or a similar base at reduced temperature
30 under an inert atmosphere. The reaction is carried out in an
31 ether-type of solvent such as a dialkyl ether or a cyclic ether, for

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1 example, tetrahydrofuran, pyran or the like.

2 More specifically, lithium diisopropylamide is generated in situ
3 by mixing diisopropylamine in a dry solvent such as tetrahydrofuran,
3| 4 which is then cooled, to between -70° and -50°C under an inert
5 atmosphere. An equimolar amount of an alkyl lithium compound such
6 as n-butyl lithium in an appropriate solvent is then added at the
7 reduced temperature and mixed for an appropriate time to permit
8 formation of lithium diisopropylamide (LDA). The ketone of formula 5
9 (at least a 10% molar excess) is dissolved in the reaction solvent, the
10 solution cooled to that of the LDA mixture, and added to that solution.
11 After brief mixing, the solution is then treated with a dialkyl
12 chlorophosphate, preferably diethyl chlorophosphate in about a 20%
13 molar excess. The reaction solution is then gradually brought to room
14 temperature. This solution is then added to a second lithium
15 diisopropylamide solution which is prepared in situ using dry solvent
16 all under an inert atmosphere, preferably argon, at reduced
3| 17 temperature (eg. -78°C). Thereafter, the reaction mixture is again
18 warmed to room temperature where it is stirred for an extended
19 period of time, preferably between 10 and 20 hours, most preferably
20 about 15 hours. The solution is then acidified and the product
21 recovered by conventional means.

22 Formula 7 compounds are prepared under conditions which
23 exclude water and oxygen. A dry, ether-type solvent such as dialkyl
24 ether or a cyclic ether such as a furan or pyran, particularly a
25 tetrahydrofuran, may be used as the solvent. A solution of formula 6
26 is first prepared under an inert atmosphere such as argon or nitrogen,
27 and then a strong base such as n-butyl lithium is added (in about a
28 10% molar excess). This reaction is begun at a reduced temperature of
3| 29 between -10° and $+10^{\circ}\text{C}$, preferably about 0°C . The reaction mixture is
30 stirred for a short period, between 30 minutes and 2 hours, and then
31 treated with about a 10% molar excess of fused zinc chloride dissolved

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/S

14¹ in the reaction solvent. This mixture is stirred for an additional 1-3
2 hours at about the starting temperature, then the temperature is
14³ increased to about ambient temperature for 10-40 minutes.

4 Where a protected heteroaromatic compound is needed to couple
5 with formula 7 compounds, such may be prepared from their
6 corresponding acids, alcohols, ketones or aldehydes. These starting
7 materials, the protected acids, alcohols, aldehydes or ketones, are all
8 available from chemical manufacturers or can be prepared by
9 published methods. Acids are esterified by refluxing the acid in a
10 solution of the appropriate alcohol in the presence of thionyl chloride.
14¹¹ Refluxing for 2-5 hours provides the desired ester. Alternatively, the
12 acid can be condensed with the appropriate alcohol in the presence of
13 dicyclohexylcarbodiimide and dimethylaminopyridine. The ester is
14 recovered and purified by conventional means. Acetals and ketals are
15 readily made by the method described in March, "Advanced Organic
16 Chemistry," 2nd Edition, McGraw-Hill Book Company, p 810). Alcohols,
17 aldehydes and ketones all may be protected by forming respectively,
18 ethers and esters, acetals or ketals by known methods such as those
19 described in McOmie, Plenum Publishing Press, 1973 and Protecting
20 Groups, Ed. Greene, John Wiley & Sons, 1981.

21 1 To increase the value of n before effecting a coupling reaction,
22 where such compounds are not available from a commercial source, the
23 heteroaromatics where B is -COOH are subjected to homologation by
24 successive treatment under Arndt-Eistert conditions or other
25 homologation procedures. These acids are then esterified by the
26 general procedure outlined in the preceding paragraph. Alternatively,
27 heteroaromatics where B is a different functional may also be
28 homologated by appropriate procedures.

29 To effect the coupling of the thiochroman moiety with those of
30 formula III, the halo-substituted heteroaromatic compound is
31 dissolved in a dry reaction solvent. The heteromatic compound is used

1 in an amount approximating the molar concentration of formula 7.
2 This solution is introduced into a suspension of
3 tetrakis-triphenylphosphine palladium (about a 5 to 10% molar
4 amount relative to the reactants) in the reaction solvent at a
3| 5 temperature of between about -10° and $+10^{\circ}\text{C}$. This mixture is stirred
6 briefly, for about 15 minutes. To this just prepared mixture is then
7 added the pre-prepared solution of formula 7, the addition being
8 made at about room temperature. This solution is stirred for an
9 extended period, between about 15 and 25 hours at room
10 temperature. The reaction is then quenched with acid and the product
11 separated and purified by conventional means to give the compounds
12 of formula I.

13 An alternative means for making compounds where n is 1 or 2 is
14 to subject the compounds of formula I where B is an acid or other
15 function to homologation using the Arndt-Eistert method referred to
16 above or other homologation procedures.

17 The acids and salts derived from formula I are readily obtainable
18 from the corresponding esters. Basic saponification with an alkali
19 metal base will provide the acid. For example, an ester of formula I
20 may be dissolved in a polar solvent such as an alkanol, preferably
21 under an inert atmosphere at room temperature, with about a three
22 molar excess of base, for example, potassium hydroxide. The solution
23 is stirred for an extended period of time, between 15 and 20 hours,
24 cooled, acidified and the hydrolysate recovered by conventional means.

25 The amide may be formed by any appropriate amidation means
26 known in the art. One way to prepare such compounds is to convert an
27 acid to an acid chloride and then treat that compound with ammonium
28 hydroxide or an appropriate amine. For example, the acid is treated
29 with an alcoholic base solution such as ethanolic KOH (in approximately
30 a 10% molar excess) at room temperature for about 30 minutes. The
31 solvent is removed and the residue taken up in an organic solvent such

1 as diethyl ether, treated with a dialkyl formamide and then a 10-fold
2 excess of oxalyl chloride. This is all effected at a moderately reduced
3 temperature between about ³¹-10° and +10°C. The last mentioned
4 solution is then stirred at the reduced temperature for 1-⁴ hours,
5 preferably 2 hours. Solvent removal provides a residue which is
6 taken up in an inert inorganic solvent such as benzene, cooled to about
7 0°C and treated with concentrated ammonium hydroxide. The
8 resulting mixture is stirred at a reduced temperature for 1-⁴ hours.
9 The product is recovered by conventional means.

10 Alcohols are made by converting the corresponding acids to the
11 acid chloride with thionyl chloride or other means (J. March,
12 "Advanced Organic Chemistry", 2nd Edition, McGraw-Hill Book
13 Company), then reducing the acid chloride with sodium borohydride
14 (March, Ibid, pg. 1124), which gives the corresponding alcohols.
15 Alternatively, esters may be reduced with lithium aluminum hydride
16 at reduced temperatures. Alkylating these alcohols with appropriate
17 alkyl halides under Williamson reaction conditions (March, Ibid,
18 pg. 357) gives the corresponding ethers. These alcohols can be
19 converted to esters by reacting them with appropriate acids in the
20 presence of acid catalysts or dicyclohexylcarbodiimide and
21 dimethylaminopyridine.

22 Aldehydes can be prepared from the corresponding primary
23 alcohols using mild oxidizing agents such as pyridinium dichromate in
24 methylene chloride (Corey, E.J., Schmidt, G., Tet. Lett., 399, 1979), or
25 dimethyl sulfoxide/oxalyl chloride in methylene chloride (Omura, K.,
26 Swern, D., Tetrahedron, 1978, 34, 1651).

27 Ketones can be prepared from an appropriate aldehyde by
28 treating the aldehyde with an alkyl Grignard reagent or similar reagent
29 followed by oxidation.

30 Acetals or ketals can be prepared from the corresponding
31 aldehyde or ketone by the method described in March, Ibid, p 810.

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1 Compounds where B is H are prepared from the corresponding
2 halo-heterocyclic entity preferably where the halogen is I. This
3 haloheterocyclic compound is reacted with the ethynyl entity or the
4 ethynyl zinc chloride entity as represented in Reaction Scheme I and as
5 illustrated in the Examples. Halo-substituted heterocyclic compounds
6 where B is H are commercially available or can be prepared by
7 methods in the literature.

8 Compounds where X is oxygen are prepared by the steps
9 outlined in Reaction Scheme III. The phosphate of formula 14 is
10 prepared from the corresponding diphenyl chlorophosphate and
11 3-methyl-3-butene-1-ol available from Aldrich or which may be
12 prepared by means known in the art. It is preferred to prepare for-
13 mula 14 by dissolving the alcohol of formula 13 in about a 10% excess
14 of pyridine in a polar inert solvent under an inert atmosphere cooled
15 to approximately ³¹-10 to 10°C. This solution is then added drop-wise,
16 under an inert atmosphere, to a solution of cooled diphenyl
17 chlorophosphate in about an equal amount of the reaction solvent.
18 About a 2-5% molar excess of diphenyl chlorophosphate relative to the
19 alcohol is ¹⁴employed. The atmosphere may be argon, nitrogen, or
20 another inert gas. The mixture is heated at reflux for between 1 and
21 5 hours, preferably about 3, to effect the reaction. The product is then
22 recovered by conventional means.

23 The diphenyl phosphate ester from the preceding paragraph
24 (formula 14) is then reacted with phenol or 3-alkylphenol to effect
25 formation of compound 16. For example, phenol is added to a flask
26 already containing stannic chloride under argon which has been cooled
27 to between ³¹-10 to 10°C. After thorough mixing of this combination for
28 about 15 minutes to an hour at the reduced temperature, the
29 phosphate is added at the reduced temperature. Both of these steps
30 are carried out under an inert atmosphere such as argon or nitrogen.
31 When the addition of the phosphate is completed, the mixture is

1 stirred at about ambient temperature for up to 24 hours. Then the
2 reaction is quenched with a dilute solution of aqueous alkali metal base
3 or the like. The product is recovered by extraction and other
4 conventional means.

5 Formula 16 is then acetylated, converted to the acetylene and
6 either the acetylene or the corresponding alkynyl zinc chloride salt
7 coupled with the appropriate heterocycle by the steps outlined in
8 Reaction Scheme I.

9 The tetrahydroquinoline moiety, that is where X is nitrogen, can
10 be made by the steps outlined in Reaction Scheme IV in part by the
11 method described in European Patent Application 0130795 published
12 September 1, 1985. First, 3-methylcrotonoyl chloride is reacted with
13 aniline to obtain the amide. This amide is then cyclized using
14 aluminum chloride in the absence of solvent. Lithium aluminum
15 hydride or another acceptable reducing agent of similar type is then
16 used to reduce the 2-oxo-1,2,3,4-tetrahydroquinoline, preferably in an
17 inert solvent such as diethyl ether. This amine is then acetylated using
18 acetyl chloride in a polar solvent such as pyridine. This protected
19 amine is then acetylated in the presence of aluminum chloride. The
20 acetyl function on the nitrogen may then be removed by base
21 hydrolysis. Then the acetylated compound is converted to the
22 acetylene and ZnCl salt as outlined in Reaction Scheme I. The
23 acetylene or the salt is then coupled with an appropriate compound of
24 formula III as described before to give compounds of formula I.

25 Reaction Scheme V sets out an alternative method for making the
26 tetrahydroquinoline compounds illustrated in Reaction Scheme IV.

27 ~~DEP~~ The following Examples are set out to illustrate the invention, not
28 to limit its scope.

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CL EXAMPLE 1
CL Phenyl-3-methylbut-2-enylsulfide

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¹ P A mixture of 14.91 g (135.324 mmol) of thiophenol and 5.5 g
² (137.5 mmol) of NaOH in 100 ml acetone was heated at reflux for
³ 2.5 hours and then treated dropwise with a solution of 20 g (134.19
⁴ mmol) of 1-bromo-3-methyl-2-butene in 20 ml acetone. This solution
⁵ was refluxed for 40 hours and then stirred at room temperature for
⁶ 24 hours. Solvent was then removed in vacuo, the residue taken up in
³³ ⁷ water, and extracted with 3x50 ml ether. Ether extracts were
L⁸ combined and washed with 3x30 ml of 5% NaOH solution, then water,
⁹ saturated NaCl solution and dried (MgSO₄). Solvent was then removed
¹⁰ in vacuo and the residue further purified by kugelrohr distillation
¹¹ (80°C, 0.75 mm) to give the title compound as a pale yellow oil.
¹² P PMR (CDCl₃): δ 1.57 (3H, s), 1.69 (3H, s), 3.52 (2H, d, J~7.7 Hz),
¹³ 5.29 (1H, t, J~7.7 Hz), 7.14 (1H, t, J~7.0 Hz), 7.24 (2H, t, J~7.0 Hz), 7.32
18 L¹⁴ (2H, d, J~7.0 Hz).

¹⁵

¹⁶

CL

EXAMPLE 2

¹⁷

L

4,4-Dimethylthiochroman

¹⁸ P To a solution of 15.48 g (86.824 mmol) of
¹⁹ phenyl-3-methylbut-2-enylsulfide (from Example 1) in 160 ml
²⁰ benzene were added successively 12.6 g (88.767 mmol) of phosphorus
²¹ pentoxide and 11 ml of 85% phosphoric acid. This solution was
²² refluxed with vigorous stirring under argon for 20 hours, then cooled
²³ to room temperature. The supernatant organic layer was decanted and
³³ ²⁴ the syrupy residue extracted with 3x50 ml ether. Organic fractions
²⁵ were combined and washed with water, saturated NaHCO₃ and
²⁶ saturated NaCl solution and then dried (MgSO₄). Solvent was removed
²⁷ in vacuo and the residue purified by kugelrohr distillation (80°C,
²⁸ 0.5 mm) to give the title compound as a pale yellow oil.
²⁹ P⁶⁷¹⁴ PMR (CDCl₃): δ 1.30 (6H, s), 1.90-1.95 (2H, m), 2.95-3.00 (2H, m),
14 ³⁰ 6.96-7.00 (2H, m), 7.04-7.07 (1H, m), 7.30-7.33 (1H, m).

³¹

This method can be used to make 7-position alkyl analogues as

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Z

1 exemplified by the following compounds:

- 2 PO 4,4,7-trimethylthiochroman;
3 4,4-dimethyl-7-ethylthiochroman;
4 4,4-dimethyl-7-propylthiochroman;
5 4,4-dimethyl-7-butylthiochroman; and
6 4,4-dimethyl-7-hexylthiochroman.

CL

EXAMPLE 3

L 4,4 Dimethyl-6-acetylthiochroman

7
8
9
10 P A solution of 14.3 g (80.21 mmol) of 4,4-dimethyl thiochroman
11 (from Example 2) and 6.76 g (86.12 mmol) of acetyl chloride in 65 ml
12 benzene was cooled in an ice bath and treated dropwise with 26.712 g
13 (102.54 mmol) of stannic chloride. The mixture was stirred at room
14 temperature for 12 hours, then treated with 65 ml water and 33 ml
15 conc. hydrogen chloride and heated at reflux for 0.5 hours. After
16 being cooled to room temperature, the organic layer was separated and
33 17 the aqueous layer extracted with 5x50 ml benzene. The recovered
18 organic fractions were combined and washed with 5% sodium
19 carbonate solution, water, saturated NaCl solution and then dried
20 (MgSO₄). The solvent was removed in vacuo and the residue purified
21 by flash chromatography (silica; 5% ethyl acetate in hexanes) followed
22 by kugelrohr distillation (150°C, 0.7 mm) to give the title compound as
23 a pale yellow oil.
24 P 6714 PMR (CDCl₃): δ 1.35 (6H, s), 1.92-1.98 (2H, m) 2.54 (3H, s),
14, 18 25 3.02-3.08 (2H, m), 7.13 (1H, d, J~8.6 Hz), 7.58 (1H, dd, J~8.6 Hz, 2 Hz),
18 26 7.99 (1H, d, J~2 Hz).

27 This same method may be used to acetylate all compounds made
28 as per Example 2.

CL

EXAMPLE 4

L 4,4-Dimethyl-6-ethynylthiochroman

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1 ρ To a solution of 1.441 g (14.2405 mmol) of diisopropylamine in
2 30 ml dry tetrahydrofuran under argon at -78°C was added dropwise
3 9 ml of 1.6 M (14.4 mmol) n-butyllithium³¹ in hexane. After stirring
4 this solution at -78°C for 1 hour, it was treated dropwise with a
5 solution of 2.95³¹ g (13.389 mmol) of
6 4,4-dimethyl-6-acetylthiochroman in 5 ml of dry tetrahydrofuran.
7 After another hour of stirring at -78°C , the solution was treated with
8 2.507 g (14.53 mmol) of diethyl chlorophosphate³¹ and brought to room
9 temperature, where it was stirred for 3.75 hours. This solution was
10 then transferred using a double ended needle to a solution of lithium
11 diisopropylamide (prepared as above using 2.882 g (28.481 mmol) of
12 diisopropylamine and 18 ml of 1.6 M (28.8 mmol) n-butyllithium in
13 hexane) in 60 ml dry tetrahydrofuran at -78°C . The cooling bath was
14 removed and the solution stirred at room temperature for 15 hours,
15 then quenched with water and acidified to pH 1 with 3N hydrogen
16 chloride. The mixture was stirred at room temperature for 12 hours,
17 then treated with 65 ml water and 33 ml conc. hydrogen chloride and
18 heated at reflux for 0.5 hours. After being cooled to room
19 temperature, the organic layer was separated and the aqueous layer
20 extracted with 5x50 ml benzene. The recovered organic fractions
21 were combined and washed with 5% sodium carbonate solution, water,
22 saturated NaCl solution and then dried (MgSO_4). The solvent was
23 removed in vacuo and the residue purified by flash chromatography
24 (silica; 5% ethyl acetate in hexanes) followed by kugelrohr distillation
25 (150°C , 0.7 mm) to give the captioned compound as a pale yellow oil.
26 ρ PMR (CDCl_3): δ 1.35 (6H, s), 1.92-1.98 (2H, m) 2.54 (3H, s),
27 3.02-3.08 (2H, m), 7.13 (1H, d, J₆₇~8.6 Hz)¹⁴, 7.58 (1H, dd, J₁₃~8.6 Hz, 2 Hz)¹³,
28 7.99 (1H, d, J~2 Hz)¹⁴.
29 ρ In the same manner, all acetyl-containing compounds prepared
30 under Example 3 may be converted to their corresponding ethynyl
31 analogues.

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CL
L EXAMPLE 5

Ethyl 6-chloronicotinate

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2
3
4 P A mixture of 15.75 g (0.1 mol) 6-chloronicotinic acid, 6.9 g
5 (0.15 mol) ethanol, 22.7 g (0.11 mol) dicyclohexylcarbodiimide and
6 3.7 g dimethylaminopyridine in 200 ml methylene chloride was
7 heated at reflux for 2 hours. The mixture was allowed to cool, solvent
8 removed in vacuo and residue subjected to flash chromatography to
9 give the title compound as a low-melting white solid.

10 P PMR (CDCl₃): δ 1.44 (3H, t, J~6.2 Hz) 4.44 (2H, q, J~4.4 Hz), 7.44
11 (1H, d, J~8.1 Hz), 8.27 (1H, dd, J~8.1 Hz, 3 Hz), 9.02 (1H, d, J~3 Hz).

12 This procedure may be used to esterify any of the other
13 halo-substituted acids employed in the making of these compounds
14 such as

15 PO ethyl 2-(2-chloropyrid-5-yl)acetate;
16 ethyl 5-(2-chloropyrid-5-yl)pentanoate;
17 ethyl 2-(2-iodofur-5-yl)acetate;
18 ethyl 5-(2-iodofur-5-yl)pentanoate;
19 ethyl 2-(2-iodothien-5-yl)acetate;
20 ethyl 5-(2-iodothien-5-yl)pentanoate;
21 ethyl 2-(3-chloropyridazin-6-yl)acetate;
22 L ethyl 5-(3-chloropyridazin-6-yl)pentanoate; and the
23 corresponding chloro, or other halo, substituted pyrimidinyl or
24 pyrazinyl analogues of such esters.

CL
L EXAMPLE 6

Ethyl 6-[2-(4,4-dimethylthiochroman-6-yl)-
ethynyl]nicotinate

25
26
27
28
29 P Reaction vessels used in this procedure were flame dried under
30 vacuum and all operations carried out in an oxygen-free, argon or
31 nitrogen atmosphere. To a solution of 465.7 mg (2.3019 mmol) of

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1 4,4-dimethyl-6-ethynyl-thiochroman in 4 ml of dry tetrahydrofuran
2 at 0°C was added dropwise 1.5 ml of 1.6 M (2.4 mmol)
3 n-butyllithium in hexane. This was stirred at 0°C for 10 minutes and
4 at room temperature for 10 minutes, cooled again to 0°C and then
5 treated with a solution of 330 mg (2.4215 mmol) of fused ZnCl₂ in
6 4 ml dry tetrahydrofuran using a double ended needle. Thereafter
7 the solution was stirred at 0°C for 30 minutes, then at room
8 temperature for 10 minutes. A solution of 426.3 mg (2.2967 mmol)
9 of ethyl 6-chloronicotinoate (from Example 5) in 4 ml dry
10 tetrahydrofuran was transferred by double ended needle into a
11 suspension of 430 mg (0.37 mmol) of tetrakis(triphenyl)phosphine
12 palladium in 4 ml dry tetrahydrofuran and stirred at room
13 temperature for 10 minutes, then treated by double ended needle
14 with the solution of the alkynylzinc prepared above. This mixture was
15 stirred at room temperature for 18 hours, then quenched with 100 ml

✓ 33 16 water. Product was recovered by extraction with 3x75 ml ether.
17 Ether fractions were combined and washed with saturated NaCl
18 solutions and dried (mgSO₄). Solvent was removed in vacuo and the
19 residue purified by flash chromatography (silica; 5% ethyl acetate in
20 hexane) followed by HPLC (Whatman Partisil M-9 10/50; 4% ethyl
21 acetate in hexane) to give the title compound as a white solid.
22 ρ PMR (CDCl₃): δ 1.36 (6H, s), 1.45 (3H, t, J~7 Hz), 1.96-2.00 (2H,
M, 18 23 m), 3.05-3.09 (2H, m), 4.45 (2H, q, J~7 Hz), 7.11 (1H, d, J~8.4 Hz), 7.29
18 24 (1H, dd, J~8.4 Hz, 2.2 Hz), 7.59 (1H, d, J~7.8 Hz), 7.66 (1H, d, J~2.2 Hz),
L 25 8.30 (1H, dd, J~7.8 Hz, 2.3 Hz), 9.22 (1H, d, J~2.3 Hz).

26 Using this method, but substituting the appropriate
27 ethynylthiochroman from Example 4 and the appropriate
28 halo-substituted heteroaromatic ester from Example 5, the following
29 compounds may be prepared:

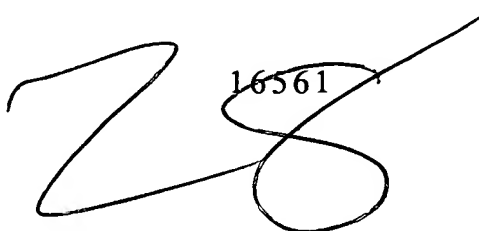
30 ρ Ethyl 6-(2(4,4,7-trimethylthiochroman-6-yl)- ethynyl)nicotinate;
31 L Ethyl 6-(2-4,4-dimethyl-7-ethylthiochroman-6-yl)-

- ¹ ethynyl)nicotinate;
- ² PO ethyl 6-(2-(4,4-dimethyl-7-propylthiochroman-6-yl)-
- ³ ethynyl)nicotinate;
- ⁴ PO ethyl 6-(2-(4,4-dimethyl-7-hexylthiochroman-6-yl)-
- ⁵ ethynyl)nicotinate;
- ⁶ PO ethyl (2-((4,4-dimethylthiochroman-6-yl)ethynyl)-
- ⁷ pyrid-5-yl)acetate;
- ⁸ PO ethyl (2-((4,4,7-trimethylthiochroman-6-yl)ethynyl)-
- ⁹ pyrid-5-yl)acetate;
- ¹⁰ PO ethyl (2-((4,4-dimethyl-7-ethylthiochroman-6-yl)-
- ¹¹ ethynyl)pyrid-5-yl)acetate;
- ¹² PO ethyl (2-((4,4-dimethyl-7-hexylthiochroman-6-yl)-
- ¹³ ethynyl)pyrid-5-yl)acetate;
- ¹⁴ PO ethyl 3-(2-((4,4-dimethylthiochrom-2-yl)-
- ¹⁵ ethynyl)pyrid-5-yl)propionate;
- ¹⁶ PO ethyl 3-(2-((4,4,7-trimethylthiochroman-6-yl)-
- ¹⁷ ethynyl)pyrid-5-yl)propionate;
- ¹⁸ PO ethyl 3-(2-((4,4-dimethyl-7-ethylthiochroman-6-yl)-
- ¹⁹ ethynyl)pyrid-5-yl)propionate;
- ²⁰ PO ethyl 3-(2-((4,4-dimethyl-7-hexylthiochroman-6-yl)-
- ²¹ ethynyl)pyrid-5-yl)propionate;
- ²² PO ethyl 5-(2-((4,4-dimethylthiochroman-6-yl)ethynyl)-
- ²³ pyrid-5-yl)pentanoate;
- ²⁴ PO ethyl 5-(2-((4,4,7-trimethylthiochroman-6-yl)-
- ²⁵ ethynyl)pyrid-5-yl)pentanoate;
- ²⁶ PO ethyl 5-(2-((4,4-dimethyl-7-ethylthiochroman-6-yl)-
- ²⁷ ethynyl)pyrid-5-yl)pentanoate;
- ²⁸ PO ethyl (5-((4,4-dimethylthiochroman-6-yl)ethynyl)-
- ²⁹ fur-2-yl)acetate;
- ³⁰ PO ethyl (5-((4,4,7-trimethylthiochroman-6-yl)ethynyl)-
- ³¹ fur-2-yl)acetate;

- 1 PO ethyl (5-((4,4-dimethyl-7-ethylthiochroman-6-yl)-
2 ethynyl)fur-2-yl)acetate;
- 3 PO ethyl (5-((4,4-dimethyl-7-hexylthiochroman-6-yl)-
4 ethynyl)fur-2-yl)acetate;
- 5 PO ethyl 5-(5-((4,4-dimethylthiochroman-6-yl)ethynyl)-
6 fur-2-yl)pentanoate;
- 7 PO ethyl 5-(5-((4,4,7-trimethylthiochroman-6-yl)-
8 ethynyl)fur-2-yl)pentanoate;
- 9 PO ethyl 5-(5-((4,4-dimethyl-7-ethylthiochroman-6-yl)-
10 ethynyl)fur-2-yl)pentanoate;
- 11 PO ethyl 5-(5-((4,4-dimethyl-7-hexylthiochroman-6-yl)-
12 ethynyl)fur-2-yl)pentanoate;
- 13 PO ethyl (5-((4,4-dimethylthiochroman-6-yl)ethynyl)-
14 thien-2-yl)acetate;
- 15 PO ethyl (5-((4,4,7-trimethylthiochroman-6-yl)ethynyl)-
16 thien-2-yl)acetate;
- 17 PO ethyl (5-((4,4-dimethyl-7-ethylthiochroman-6-yl)-
18 ethynyl)thien-2-yl)acetate;
- 19 PO ethyl (5-((4,4-dimethyl-7-hexylthiochroman-6-yl)-
20 ethynyl)thien-2-yl)acetate;
- 21 PO ethyl 5-(5-((4,4-dimethylthiochroman-6-yl)ethynyl)-
22 thien-2-yl)pentanoate;
- 23 PO ethyl 5-(5-((4,4,7-trimethylthiochroman-6-yl)-
24 ethynyl)thien-2-yl)pentanoate;
- 25 PO ethyl 5-(5-((4,4-dimethyl-7-ethylthiochroman-6-yl)-
26 ethynyl)thien-2-yl)pentanoate;
- 27 PO ethyl 5-(5-((4,4-dimethyl-7-hexylthiochroman-6-yl)-
28 ethynyl)thien-2-yl)pentanoate;
- 29 PO ethyl (6-((4,4-dimethylthiochroman-6-yl)ethynyl)-
30 pyridazin-3-yl)acetate;
- 31 PO ethyl (6-((4,4,7-trimethylthiochroman-6-yl)ethynyl)-

- ¹ pyridazin-3-yl)acetate;
- ² PO ethyl (6-((4,4-dimethyl-7-ethylthiochroman-6-yl)-
- ³ ethynyl)pyridazin-3-yl)acetate;
- ⁴ PO ethyl (6-((4,4-dimethyl-7-hexylthiochroman-6-yl)-
- ⁵ ethynyl)pyridazin-3-yl)acetate;
- ⁶ PO ethyl 5-(6-((4,4-dimethylthiochroman-6-yl)ethynyl)-
- ⁷ pyridazin-3-yl)pentanoate;
- ⁸ PO ethyl 5-(6-((4,4,7-trimethylthiochroman-6-yl)-
- ⁹ ethynyl)pyridazin-3-yl)pentanoate;
- ¹⁰ PO ethyl 5-(6-((4,4-dimethyl-7-ethylthiochroman-6-yl)-
- ¹¹ ethynyl)pyridazin-3-yl)pentanoate;
- ¹² PO ethyl 5-(6-((4,4-dimethyl-7-hexylthiochroman-6-yl)-
- ¹³ ethynyl)pyridazin-3-yl)pentanoate;
- ¹⁴ PO ethyl (5-((4,4-dimethylthiochroman-6-yl)ethynyl)-
- ¹⁵ pyrimidin-2-yl)acetate;
- ¹⁶ PO ethyl (5-((4,4,7-trimethylthiochroman-6-yl)ethynyl)-
- ¹⁷ pyrimidin-2-yl)acetate;
- ¹⁸ PO ethyl (5-((4,4-dimethyl-7-ethylthiochroman-6-yl)-
- ¹⁹ ethynyl)pyrimidin-2-yl)acetate;
- ²⁰ PO ethyl (5-((4,4-dimethyl-7-hexylthiochroman-6-yl)-
- ²¹ ethynyl)pyrimidin-2-yl)acetate;
- ²² PO ethyl 5-(5-((4,4-dimethylthiochroman-6-yl)ethynyl)-
- ²³ pyrimidin-2-yl)pentanoate;
- ²⁴ PO ethyl 5-(5-((4,4,7-trimethylthiochroman-6-yl)-
- ²⁵ ethynyl)pyrimidin-2-yl)pentanoate;
- ²⁶ PO ethyl 5-(5-((4,4-dimethyl-7-ethylthiochroman-6-yl)-
- ²⁷ ethynyl)pyrimidin-2-yl)pentanoate;
- ²⁸ PO ethyl 5-(5-((4,4-dimethyl-7-hexylthiochroman-6-yl)-
- ²⁹ ethynyl)pyrimidin-2-yl)pentanoate;
- ³⁰ PO ethyl (5-((4,4-dimethylthiochroman-6-yl)ethynyl)-
- ³¹ pyrazin-2-yl)acetate;

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1 PO ethyl (5-((4,4,7-trimethylthiochroman-6-yl)ethynyl)-
2 pyrazin-2-yl)acetate;

3 PO ethyl (5-((4,4-dimethyl-7-ethylthiochroman-6-yl)-
4 ethynyl)pyrazin-2-yl)acetate;

5 PO ethyl (5-((4,4-dimethyl-7-hexylthiochroman-6-yl)-
6 ethynyl)pyrazin-2-yl)acetate;

7 PO ethyl 5-((4,4-dimethylthiochroman-6-yl)ethynyl)-
8 pyrazin-2-yl)pentanoate;

9 PO ethyl 5-(5-((4,4,7-trimethylthiochroman-6-yl)-
10 ethynyl)pyrazin-2-yl)pentanoate;

11 PO ethyl 5-(5-((4,4-dimethyl-7-ethylthiochroman-6-yl)-
12 ethynyl)pyrazin-2-yl)pentanoate; and

13 PO ethyl 5-(5-((4,4-dimethyl-7-hexylthiochroman-6-yl)-
14 ethynyl)pyrazin-2-yl)pentanoate.

15 P Alternative synthesis: The title compound of Example 6, ethyl
16 6-[2-(4,4-dimethylthiochroman-6-yl)ethynyl]nicotinate, was also
17 prepared as follows. 9

18 A solution of 15.4 g (76.2 mmol) of 4,4-dimethyl-6-ethynyl-
19 thiochroman and 14.0 g (75.5 mmol) of ethyl-6-chloronicotinate in
20 35 ml of freshly distilled triethylamine was degassed and then treated
21 under nitrogen with a finely powdered mixture of 1 g (5.25 mmol) of
22 high purity cuprous iodide and 2 g (2.85 mmol) of
23 bis(triphenylphosphine) palladium (II) chloride. The mixture was
24 heated under nitrogen at 55°C for 20 hours and then cooled to room
25 temperature. The triethylamine was then removed under vacuum and
26 the residue was diluted with 200 ml of a 1:4 mixture of ethyl acetate
27 and hexanes. This mixture was filtered through silica and the filtrate
28 concentrated in vacuo. The resultant residue was purified by flash
29 chromatography (silica gel; 15% ethyl acetate in hexanes) and recryst-
30 tallized from a mixture of ethyl acetate and hexanes to give the title
31 compound as a pale yellow solid.

CL₂

Example 7

CL (3-Methyl-4-bromo-phenyl)-3-methylbut-2-enylsulfide

To a stirred solution of 9.52 g (68 mmol) of 3-methyl-4-bromothiophenol in 80 ml of acetone was added 2.86 g (68 mmol) of powdered sodium hydroxide. This mixture was stirred until the components were dissolved. The reaction mixture was then heated to reflux, and then treated with a solution of 11.26 g (68 mmol) of 4-bromo-2-methyl-2-butene in 20 ml of acetone. The mixture was heated at reflux for a further 0.5 hour, cooled to room temperature and the solvent removed in vacuo. The residue was taken up in 35 ml of water and extracted with ether. The ether extracts were combined and washed successively with water and saturated NaCl solution and then dried (MgSO₄). The solvent was removed in vacuo and the residue kugelrohr distilled (140 - 145°C, 0.2 mm) to give the title compound as a colorless oil.

PMR (CDCl₃): δ 1.58 (3H, s), 1.70 (3H, s), 2.33 (3H, s), 3.49 (2H, d, J~7.8 Hz), 5.26 (1H, t, J~7.8 Hz), 6.98 (1H, dd, J~8.3 Hz, 2.3 Hz), 7.17 (1H, d J~2.3 Hz), 7.38 (1H, d, J~8.3 Hz).

CL₂

Example 8

CL 4,4,7-Trimethyl-6-bromothiochroman

To 40 g of a vigorously stirred mixture of 10% phosphorous pentoxide in methanesulfonic acid was added slowly 6.0 g (28.8 mmol) of (3-methyl-4-bromophenyl)-3-methylbut-2-enylsulfide. The mixture was stirred at room temperature for a further 2 hours and was then poured onto ice. The mixture was extracted with 2 x 40 ml of ether and the combined ether extracts were washed successively with water and saturated NaCl solution and then dried. The solvent was removed in vacuo and the residue distilled using a kugelrohr apparatus (130°C; 0.07 mm) to give the title compound as a viscous oil.

PMR (CDCl₃): δ 1.28 (6H, s), 1.84-1.93 (2H, m), 2.26 (3H, s),

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¹⁴ 2.95-3.03 (2H, m), 6.94 (1H, s), 7.46 (1H, s).

²
³ CL₇ Example 9

⁴ CL 4,4,7-Trimethyl-6-trimethylsilylethynylthiochroman

⁵ A mixture of 624 mg (3.0 mmol) of 4,4,7-trimethyl-6-
⁶ bromothiochroman, 314 mg (3.2 mmol) of trimethylsilylacetylene, 40
⁷ mg (0.21 mmol) of cuprous iodide, 80 mg (0.11 mmol) of bis-(triphe-
⁸ nylphosphine) palladium (II) chloride and 1 ml of triethylamine was
⁹ degassed under nitrogen and heated in a sealed tube at 85°C for 15
¹⁰ hours. The mixture was then treated with a further 20 mg (0.11
¹¹ mmol) of cuprous iodide and 40 mg (0.06 mmol) of the palladium (II)
¹² catalyst. The mixture was then heated under a nitrogen atmosphere in
¹³ the sealed tube at 100°C for a further 64 hours. The triethylamine was
¹⁴ then removed under vacuum and the residue purified by flash
¹⁵ chromatography (silica; hexanes) to give the title compound as a yellow
¹⁶ oil.

¹⁷ ¹⁴ PMR (CDCl₃): ⁶⁷δ 0.28 (9H, s), 1.30 (6H, s), 1.88-1.97 (2H, m), 2.33
¹⁸ (3H, s), 2.97-3.05 (2H, m), 6.92 (1H, s), 7.43 (1H, s).

¹⁹
²⁰ CL₇ Example 10

²¹ CL 4,4,7-Trimethyl-6-ethynylthiochroman

²² A mixture of 380 mg (1.69 mmol) of 4,4,7-trimethyl-6-
²³ trimethylsilylethynylthiochroman, 4 ml of isopropanol and 2.5 ml of
²⁴ aqueous 1N potassium hydroxide was degassed under nitrogen and
²⁵ stirred at room temperature for 16 hours. The mixture was
²⁶ concentrated under vacuum and extracted with 2 x 10 ml of ether.
²⁷ The ether extracts were combined and washed successively with water
²⁸ and saturated NaCl solution and then dried (MgSO₄). The solvent was
²⁹ removed in vacuo to give the title compound as a yellow oil.

³⁰ PMR (CDCl₃): ⁶⁷δ 1.31 (6H, s), 1.88-1.96 (2H, m), 2.35 (3H, s),
³¹ 3.00-3.08 (2H, m), 3.25 (1H, s), 6.94 (1H, s), 7.47 (1H, s).

1

2 *CL₂*

Example 11

3 *CL* Ethyl 6-[2-(4,4,7-trimethylthiochroman-6-yl)ethynyl]nicotinate

4 *P* A mixture of 86 mg (0.4 mmol) of 4,4,7-trimethyl-6-ethynyl-
5 thiochroman, 85 mg (0.46 mmol) of ethyl 6-chloronicotinate and 0.8 ml
6 of triethylamine was degassed under nitrogen and then treated with a
7 mixture of 10 mg (0.05 mmol) of cuprous iodide and 20 mg (0.03
8 mmol) of bis(triphenylphosphine) palladium (II) chloride. The reaction
9 mixture was heated at 55°C under a nitrogen atmosphere for 18 hours.
10 The mixture was then extracted with 1.5 ml of 40% ethyl acetate in
11 hexanes and purified by flash chromatography (silica; 10% ethyl
12 acetate in hexanes) to give the title compound as a yellow solid.

13 *P* PMR (CDCl₃): δ 1.32 (6H, s), 1.43 (3H, t, J~7.2 Hz), 2.44 (3H, s),
14, 18 3.01-3.05 (2H, m), 4.42 (2H, q, J~7.2 Hz), 6.98 (1H, s), 7.54-7.63 (2H, m),
18 8.27 (1H, dd, J~8.3 Hz, 2.3 Hz), 9.21 (1H, d, J~2.3 Hz).

16

17

CL₂

Example 12

18 *CL* Ethyl 5-(2-(4,4-dimethyl-thiochroman-6-yl)ethynyl)-
19 thiophene-2-carboxylate

20 *P* Using the same general procedure described in the preceeding
21 Example 11, but using instead 4,4-dimethyl-6-ethynylthiochroman and
22 ethyl 5-bromothiophene-2-carboxylate, the title compound was syn-
23 thesized.

24 *P* PMR (CDCl₃): δ 1.31 (6H, s), 1.36 (3H, t, J~7.5 Hz), 1.90-1.94 (2H,
14, 18 m), 2.99-3.03 (2H, m), 4.33 (2H, q, J~7.5 Hz), 7.04 (1H, d, J~8.1 Hz),
14, 18 7.13-7.18 (2H, m), 7.50 (1H, s), 7.65 (1H, d, J~3.9 Hz).

27

28

CL₂

Example 13

29 *CL* Ethyl-5-(2-(4,4-dimethylthiochroman-6-yl)ethynyl)-2-furoate

30 *P* Again using the general procedure of Example 11, but using
31 instead 4,4-dimethyl-6-ethynylthiochroman and ethyl 5-bromo-2-fu-

32

¹ rate, the title compound was synthesized.

² P PMR (CDCl₃): δ 1.24 (6H, s), 1.31 (3H, t, J₈₋₇ 7.0 Hz), 1.83-1.87 (2H, m), 2.93-2.97 (2H, m), 4.30 (2H, q, J₇₋₆ 7.0 Hz), 6.60 (1H, d, J₃₋₄ 3.4 Hz), 6.98 (1H, d, J₅₋₆ 8.1 Hz), 7.09-7.11 (2H, m), 7.46 (1H, d, J₁₋₂ 1.7 Hz).

EXAMPLE 14

CC Diphenyl-3-methyl-3-buten-1-yl phosphate

8 ρ To an ice-cooled solution of 12.2 g (141.65 mmol) of
9 3-methyl-3-buten-1-ol (Aldrich) and 11.9 g (150.44 mmol) of pyridine
10 in 100 ml of tetrahydrofuran was added dropwise under argon a
11 solution of 38.5 g (143.21 mmol) of diphenyl chlorophosphate 93 in
12 100 ml of tetrahydrofuran. The mixture was heated at reflux for 3
13 hours and then cooled and filtered. The filtrate was concentrated in
14 vacuo and the residue dissolved in 400 ml of 1:1 ether and hexane and
33 15 then washed with 2 x 200 ml water, 75 ml saturated NaCl solution and
16 dried (MgSO₄). The solvent was removed in vacuo to give the
17 captioned compound as a pale yellow oil.

¹⁸ ρ PMR (CDCl₃): δ 1.69 (3H, M), 2.37 (2H, t, J N7 Hz), 4.32 (2H, q, J 7-
¹⁹ Hz), 4.72 (1H, M), 7.10-7.35 (10H, m).

EXAMPLE 15

4,4-Dimethylchroman

To a dry, ice-cooled flask containing 34.95 g (0.134 mol) of stannic chloride was added quickly under argon 63.0 g (0.669 mol) of phenol. The mixture was stirred at 0°C for 0.5 hour and then treated with 43.0 g (0.135 mol) of diphenyl-3-methyl-3-buten-1-yl phosphate, followed by a 5 ml carbon disulfide rinse. The mixture was stirred at room temperature for 21 hours and then quenched by pouring onto 700 g ice and 1 liter of 1.5N NaOH. The mixture was extracted with 1 x 600 ml and 2 x 300 ml ether. The combined ether fractions were washed with 2N NaOH, saturated NaCl

16561

1 and dried (MgSO₄). Solvent was removed in vacuo and the residue
2 purified by flash chromatography (silica; 2% ether in hexane) to give
3 the title compound as a colorless oil.

4 ρ PMR (CDCl₃): δ 1.34 (6H, M), 1.80-1.85 (2H, m), 4.15₄-4.20 (2H, m),
18 5 6.80 (1H, dd, J~8.1 Hz, 1.5 Hz), 6.87 (1H, td, J~8.1 Hz, 1.5 Hz), 7.07 (1H,
L 6 td, J~8.1 Hz, 1.5 Hz), 7.26 (1H, dd, J~8.1 Hz, 1.5 Hz).

7 ρ This method also serves to prepare the corresponding
8 7-alkylchroman compounds, starting with the appropriate 3-alkylphe-
9 nol, for example:

10 PO 4,4,7-trimethylchroman;
11 L 4,4-dimethyl-7-ethylchroman;
12 4,4-dimethyl-7-propylchroman;
13 4,4-dimethyl-7-butylchroman;
14 4,4-dimethyl-7-pentylchroman; and
15 L 4,4-dimethyl-7-hexylchroman.

17 CL EXAMPLE 16

18 L 4,4-Dimethyl-6-acetylchroman

19 ρ To a stirred solution of 7.94 g (48.9425 mmol) of
20 4,4-dimethylchroman in 70 ml of nitromethane was added under
21 argon 4.0 g (50.96 mmol) of acetyl chloride followed by 6.8 g (51
22 mmol) of aluminum chloride. This was stirred at room temperature for
23 5.5 hours and then cooled in an ice bath and treated slowly with 70 ml
24 6N hydrogen chloride. The resultant mixture was stirred at room
25 temperature for 10 minutes, then treated with 100 ml ether and the
26 organic layer separated. The organic layer was washed with water,
27 saturated NaHCO₃ and saturated NaCl solutions and dried (MgSO₄).
28 Solvent was removed in vacuo and the residue purified by flash
29 chromatography (silica; 10% ethyl acetate in hexanes). This was
14 30 followed by kugelrohr distillation (95-100°C; 0.15 mm) to give the title
31 compound as a colorless oil.

1 P.67 PMR (CDCl₃): δ 1.40 (6H, M), 1.95-2.00 (2H, m), 2.58 (3H, M),
14 15 2 4.25-4.30 (2H, m), 6.83 (1H, d, J~8.0 Hz), 7.62 (1H, dd, J~8.0 Hz, 1.5 Hz),
18 3 8.00 (1H, d, J~1.5 Hz).

4 P Following the same procedure and using the compounds of
5 Example 15, the following compounds can be prepared:

6 PO 4,4-dimethyl-6-acetyl-7-methylchroman;
7 4,4-dimethyl-6-acetyl-7-ethylchroman;
8 4,4-dimethyl-6-acetyl-7-propylchroman;
9 4,4-dimethyl-6-acetyl-7-butylchroman;
10 4,4-dimethyl-6-acetyl-7-pentylchroman; and
11 L 4,4-dimethyl-6-acetyl-7-hexylchroman.

12
13 CL
14 L
15 EXAMPLE 17

4,4-Dimethyl-6-ethynylchroman

16 P To a solution of 2.47 g (24.41 mmol) of diisopropylamine in 40
31 16 ml dry tetrahydrofuran under argon at -78°C was added dropwise 15.2
17 ml of 1.6 M (24.32 mmol) n-butyl lithium in hexane. Mixture was
31 18 stirred at -78°C for 1 hour and then treated dropwise with a solution of
19 4.98 g (24.38 mmol) of 4,4-dimethyl-6-acetylchroman in 4 ml of dry
31 20 tetrahydrofuran. After stirring at -78°C for 1 hour, the solution was
21 treated with 4.2 g (24.36 mmol) of diethyl chlorophosphate. The
22 cooling bath was then removed and mixture stirred at room
23 temperature for 2.75 hours. This solution was then transferred using a
24 double ended needle to a solution of lithium diisopropyl amide
25 (prepared as per Example 4) using 4.95 g (48.92 mmol) of
26 diisopropylamine and 30.5 ml of 1.6 M (48.8 mmol) n-butyl lithium in
31 27 hexane in 80 ml dry tetrahydrofuran at -78°C. The cooling bath was
28 removed and mixture stirred at room temperature for 18 hours and
29 then quenched with 50 ml water and 25 ml of 3N hydrogen chloride.
33 30 The mixture was extracted with 2 x 100 ml and 3 x 50 ml of pentane
31 and the combined organic fractions washed with 3N hydrogen chloride,

1 water, saturated NaHCO_3 and saturated NaCl solution and then dried
2 (MgSO_4). Solvent was then removed in vacuo and the residue purified
3 by flash chromatography (silica; 10% ethyl acetate in hexane) followed
4 by kugelrohr distillation (70°C ; 0.35 mm) to give the title compound as
5 a colorless crystalline solid.

6 ^{14,15} ¹⁶ ¹⁷ ¹⁸ ¹⁹ ²⁰ ²¹ ²² ²³ ²⁴ ²⁵ ²⁶ ²⁷ ²⁸ ²⁹ ³⁰ ³¹ ³² ³³ ³⁴ ³⁵ ³⁶ ³⁷ ³⁸ ³⁹ ⁴⁰ ⁴¹ ⁴² ⁴³ ⁴⁴ ⁴⁵ ⁴⁶ ⁴⁷ ⁴⁸ ⁴⁹ ⁵⁰ ⁵¹ ⁵² ⁵³ ⁵⁴ ⁵⁵ ⁵⁶ ⁵⁷ ⁵⁸ ⁵⁹ ⁶⁰ ⁶¹ ⁶² ⁶³ ⁶⁴ ⁶⁵ ⁶⁶ ⁶⁷ ⁶⁸ ⁶⁹ ⁷⁰ ⁷¹ ⁷² ⁷³ ⁷⁴ ⁷⁵ ⁷⁶ ⁷⁷ ⁷⁸ ⁷⁹ ⁸⁰ ⁸¹ ⁸² ⁸³ ⁸⁴ ⁸⁵ ⁸⁶ ⁸⁷ ⁸⁸ ⁸⁹ ⁹⁰ ⁹¹ ⁹² ⁹³ ⁹⁴ ⁹⁵ ⁹⁶ ⁹⁷ ⁹⁸ ⁹⁹ ¹⁰⁰ ¹⁰¹ ¹⁰² ¹⁰³ ¹⁰⁴ ¹⁰⁵ ¹⁰⁶ ¹⁰⁷ ¹⁰⁸ ¹⁰⁹ ¹¹⁰ ¹¹¹ ¹¹² ¹¹³ ¹¹⁴ ¹¹⁵ ¹¹⁶ ¹¹⁷ ¹¹⁸ ¹¹⁹ ¹²⁰ ¹²¹ ¹²² ¹²³ ¹²⁴ ¹²⁵ ¹²⁶ ¹²⁷ ¹²⁸ ¹²⁹ ¹³⁰ ¹³¹ ¹³² ¹³³ ¹³⁴ ¹³⁵ ¹³⁶ ¹³⁷ ¹³⁸ ¹³⁹ ¹⁴⁰ ¹⁴¹ ¹⁴² ¹⁴³ ¹⁴⁴ ¹⁴⁵ ¹⁴⁶ ¹⁴⁷ ¹⁴⁸ ¹⁴⁹ ¹⁵⁰ ¹⁵¹ ¹⁵² ¹⁵³ ¹⁵⁴ ¹⁵⁵ ¹⁵⁶ ¹⁵⁷ ¹⁵⁸ ¹⁵⁹ ¹⁶⁰ ¹⁶¹ ¹⁶² ¹⁶³ ¹⁶⁴ ¹⁶⁵ ¹⁶⁶ ¹⁶⁷ ¹⁶⁸ ¹⁶⁹ ¹⁷⁰ ¹⁷¹ ¹⁷² ¹⁷³ ¹⁷⁴ ¹⁷⁵ ¹⁷⁶ ¹⁷⁷ ¹⁷⁸ ¹⁷⁹ ¹⁸⁰ ¹⁸¹ ¹⁸² ¹⁸³ ¹⁸⁴ ¹⁸⁵ ¹⁸⁶ ¹⁸⁷ ¹⁸⁸ ¹⁸⁹ ¹⁹⁰ ¹⁹¹ ¹⁹² ¹⁹³ ¹⁹⁴ ¹⁹⁵ ¹⁹⁶ ¹⁹⁷ ¹⁹⁸ ¹⁹⁹ ²⁰⁰ ²⁰¹ ²⁰² ²⁰³ ²⁰⁴ ²⁰⁵ ²⁰⁶ ²⁰⁷ ²⁰⁸ ²⁰⁹ ²¹⁰ ²¹¹ ²¹² ²¹³ ²¹⁴ ²¹⁵ ²¹⁶ ²¹⁷ ²¹⁸ ²¹⁹ ²²⁰ ²²¹ ²²² ²²³ ²²⁴ ²²⁵ ²²⁶ ²²⁷ ²²⁸ ²²⁹ ²³⁰ ²³¹ ²³² ²³³ ²³⁴ ²³⁵ ²³⁶ ²³⁷ ²³⁸ ²³⁹ ²⁴⁰ ²⁴¹ ²⁴² ²⁴³ ²⁴⁴ ²⁴⁵ ²⁴⁶ ²⁴⁷ ²⁴⁸ ²⁴⁹ ²⁵⁰ ²⁵¹ ²⁵² ²⁵³ ²⁵⁴ ²⁵⁵ ²⁵⁶ ²⁵⁷ ²⁵⁸ ²⁵⁹ ²⁶⁰ ²⁶¹ ²⁶² ²⁶³ ²⁶⁴ ²⁶⁵ ²⁶⁶ ²⁶⁷ ²⁶⁸ ²⁶⁹ ²⁷⁰ ²⁷¹ ²⁷² ²⁷³ ²⁷⁴ ²⁷⁵ ²⁷⁶ ²⁷⁷ ²⁷⁸ ²⁷⁹ ²⁸⁰ ²⁸¹ ²⁸² ²⁸³ 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1 stirred at room temperature for 20 hours and then quenched with ice
2 and 30 ml of 3N hydrogen chloride. The mixture was extracted with
3 3x75 ml ether and ether extracts were combined and washed
4 successively with saturated NaHCO_3 and saturated NaCl and then dried
5 (MgSO_4). Solvent was removed in vacuo and the residue further
6 purified by flash chromatography (silica; 10% ethyl acetate in hexane)
7 to give the
8 title compound as a yellow solid.

9 ρ PMR (CDCl_3): δ 1.36 (6H, s), 1.44 (3H, t, $J_{1,2}$ 7.1 Hz), 1.83-1.87 (2H,
10 m), 4.22-4.26 (2H, m), 4.44 (2H, q, $J_{1,2}$ 7.1 Hz), 6.80 (1H, d, $J_{1,2}$ 7.6 Hz),
11 7.35 (1H, d, $J_{1,2}$ 8.9 Hz), 7.58 (1H, d, $J_{1,2}$ 7.6 Hz), 7.60 (1H, M), 8.28 (1H, d,
12 $J_{1,2}$ 8.9 Hz), 9.21 (1H, s).

13 By this method, using the appropriate precursors, the following
14 compounds are prepared:

15 ρ ethyl 6-(2-(4,4,7-trimethylchroman-6-yl)-ethynyl)nicotinate;

16 L ethyl 6-(2-(4,4-dimethyl-7-ethylchroman-6-yl)-
17 ethynyl)nicotinate;

18 ρ ethyl 6-(2-(4,4-dimethyl-7-propylchroman-6-yl)-
19 ethynyl)nicotinate;

20 ρ ethyl 6-(2-(4,4-dimethyl-7-hexylchroman-6-yl)-
21 ethynyl)nicotinate;

22 ρ ethyl (2-((4,4-dimethylchroman-6-yl)ethynyl)-
23 pyrid-5-yl)acetate;

24 ρ ethyl (2-((4,4,7-trimethylchroman-6-yl)ethynyl)-
25 pyrid-5-yl)acetate;

26 ρ ethyl (2-((4,4-dimethyl-7-ethylchroman-6-yl)-
27 ethynyl)pyrid-5-yl)acetate;

28 ρ ethyl (2-((4,4-dimethyl-7-hexylchroman-6-yl)-
29 ethynyl)pyrid-5-yl)acetate;

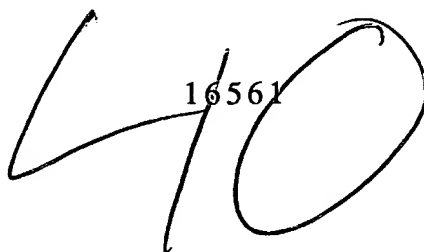
30 ρ ethyl 3-(2-((4,4-dimethylchroman-2-yl)-
31 ethynyl)pyrid-5-yl)propionate;

- ¹ PO ethyl 3-(2-((4,4,7-trimethylchroman-6-yl)-ethynyl)-
² pyrid-5-yl)propionate;
- ³ PO ethyl 3-(2((4,4-dimethyl-7-ethylchroman-6-yl)-
⁴ ethynyl)pyrid-5-yl)propionate;
- ⁵ PO ethyl 3-(2((4,4-dimethyl-7-hexylchroman-6-yl)-
⁶ ethynyl)pyrid-5-yl)propionate;
- ⁷ PO ethyl 5-(2-((4,4-dimethylchroman-6-yl)ethynyl)-
⁸ pyrid-5-yl)pentanoate;
- ⁹ PO ethyl 5-(2-((4,4,7-trimethylchroman-6-yl)-
¹⁰ ethynyl)pyrid-5-yl)pentanoate;
- ¹¹ PO ethyl 5-(2-((4,4-dimethyl-7-ethylchroman-6-yl)-
¹² ethynyl)pyrid-5-yl)pentanoate;
- ¹³ PO ethyl 5-(2-(4,4-dimethyl-7-hexylchroman-6-yl-ethynyl)
¹⁴ pyrid-5-yl)pentanoate;
- ¹⁵ PO ethyl 5-(2-((4,4-dimethylchroman-6-yl)ethynyl)-
¹⁶ fur-2-yl)acetate;
- ¹⁷ PO ethyl (5-((4,4,7-trimethylchroman-6-yl)ethynyl)-
¹⁸ fur-2-yl)acetate;
- ¹⁹ PO ethyl (5-((4,4-dimethyl-7-ethylchroman-6-yl)-
²⁰ ethynyl)fur-2-yl)acetate;
- ²¹ PO ethyl (5-((4,4-dimethyl-7-hexylchroman-6-yl)-
²² ethynyl)fur-2-yl)acetate;
- ²³ PO ethyl 5-(5-((4,4-dimethylchroman-6-yl)ethynyl)-
²⁴ fur-2-yl)pentanoate;
- ²⁵ PO ethyl 5-(5-((4,4,7-trimethylchroman-6-yl)-
²⁶ ethynyl)fur-2-yl)pentanoate;
- ²⁷ PO ethyl 5-(5-((4,4-dimethyl-7-ethylchroman-6-yl)-
²⁸ ethynyl)fur-2-yl)pentanoate;
- ²⁹ PO ethyl 5-(5-((4,4-dimethyl-7-hexylchroman-6-yl)-
³⁰ ethynyl)fur-2-yl)pentanoate;
- ³¹ PO ethyl (5-((4,4-dimethylchroman-6-yl)ethynyl)-

- ¹ thien-2-yl)acetate;
- ² PO ethyl (5-((4,4,7-trimethylchroman-6-yl)ethynyl)-
- ³ thien-2-yl)acetate;
- ⁴ PO ethyl (5-((4,4-dimethyl-7-ethylchroman-6-yl)-
- ⁵ ethynyl)thien-2-yl)acetate;
- ⁶ PO ethyl (5-((4,4-dimethyl-7-hexylchroman-6-yl)-
- ⁷ ethynyl)thien-2-yl)acetate;
- ⁸ PO ethyl 5-(5-((4,4-dimethylchroman-6-yl)ethynyl)-
- ⁹ thien-2-yl)pentanoate;
- ¹⁰ PO ethyl 5-(5-((4,4,7-trimethylchroman-6-yl)-ethynyl)-
- ¹¹ thien-2-yl)pentanoate;
- ¹² PO ethyl 5-(5-((4,4-dimethyl-7-ethylchroman-6-yl)-
- ¹³ ethynyl)thien-2-yl)pentanoate;
- ¹⁴ PO ethyl 5-(5-((4,4-dimethyl-7-hexylchroman-6-yl)-
- ¹⁵ ethynyl)thien-2-yl)pentanoate;
- ¹⁶ PO ethyl (6-((4,4-dimethylchroman-6-yl)ethynyl)-
- ¹⁷ pyridazin-3-yl)acetate;
- ¹⁸ PO ethyl (6-((4,4,7-trimethylchroman-6-yl)ethynyl)-
- ¹⁹ pyridazin-3-yl)acetate;
- ²⁰ PO ethyl (6-((4,4-dimethyl-7-ethylchroman-6-yl)-
- ²¹ ethynyl)pyridazin-3-yl)acetate;
- ²² PO ethyl (6-((4,4-dimethyl-7-hexylchroman-6-yl)-
- ²³ ethynyl)pyridazin-3-yl)acetate;
- ²⁴ PO ethyl 5-(6-((4,4-dimethylchroman-6-yl)ethynyl)-
- ²⁵ pyridazin-3-yl)pentanoate;
- ²⁶ PO ethyl 5-(6-((4,4,7-trimethylchroman-6-yl)-ethynyl)-
- ²⁷ pyridazin-3-yl)pentanoate;
- ²⁸ PO ethyl 5-(6-((4,4-dimethyl-7-ethylchroman-6-yl)-
- ²⁹ ethynyl)pyridazin-3-yl)pentanoate;
- ³⁰ PO ethyl 5-(6-((4,4-dimethyl-7-hexylchroman-6-yl)-
- ³¹ ethynyl)pyridazin-3-yl)pentanoate;

- 1 **PO** ethyl (5-((4,4-dimethylchroman-6-yl)ethynyl)-
2 pyrimidin-2-yl)acetate;
- 3 **PO** ethyl (5-((4,4,7-trimethylchroman-6-yl)ethynyl)-
4 pyrimidin-2-yl)acetate;
- 5 **PO** ethyl (5-((4,4-dimethyl-7-ethylchroman-6-yl)-
6 ethynyl)pyrimidin-2-yl)acetate;
- 7 **PO** ethyl (5-((4,4-dimethyl-7-hexylchroman-6-yl)-
8 ethynyl)pyrimidin-2-yl)acetate;
- 9 **PO** ethyl 5-(5-((4,4-dimethylchroman-6-yl)ethynyl)-
10 pyrimidin-2-yl)pentanoate;
- 11 **PO** ethyl 5-(5-((4,4,7-trimethylchroman-6-yl)-ethynyl)-
12 pyrimidin-2-yl)pentanoate;
- 13 **PO** ethyl 5-(5-((4,4-dimethyl-7-ethylchroman-6-yl)-
14 ethynyl)pyrimidin-2-yl)pentanoate;
- 15 **PO** ethyl 5-(5-((4,4-dimethyl-7-hexylchroman-6-yl)-
16 ethynyl)pyrimidin-2-yl)pentanoate;
- 17 **PO** ethyl (5-((4,4-dimethylchroman-6-yl)ethynyl)-
18 pyrazin-2-yl)acetate;
- 19 **PO** ethyl (5-((4,4,7-trimethylchroman-6-yl)ethynyl)-
20 pyrazin-2-yl)acetate;
- 21 **PO** ethyl (5-((4,4-dimethyl-7-ethylchroman-6-yl)-
22 ethynyl)pyrazin-2-yl)acetate;
- 23 **PO** ethyl (5-((4,4-dimethyl-7-hexylchroman-6-yl)-
24 ethynyl)pyrazin-2-yl)acetate;
- 25 **PO** ethyl 5-(5-((4,4-dimethylchroman-6-yl)ethynyl)-
26 pyrazin-2-yl)pentanoate;
- 27 **PO** ethyl 5-(5-((4,4,7-trimethylchroman-6-yl)-ethynyl)-
28 pyrazin-2-yl)pentanoate;
- 29 **PO** ethyl 5-(5-((4,4-dimethyl-7-ethylchroman-6-yl)-
30 ethynyl)pyrazin-2-yl)pentanoate; and
- 31 **PO** ethyl 5-(5-((4,4-dimethyl-7-hexylchroman-6-yl)-

16561



1 ethynyl)pyrazin-2-yl)pentanoate.

2

3

CL₂

Example 19

4

CL

N-(4-Bromophenyl)-3,3-dimethylacrylamide

5

6 To a solution of 9.48 g (80 mmol) of 3,3-dimethylacryloyl
7 chloride in 200 ml of dry tetrahydrofuran (THF) was added with
8 vigorous shaking a solution of 13.76 g (80 mmol) of 4-bromoaniline in
9 300 ml of dry THF. The mixture stood at room temperature for 2
10 hours and was then treated with 80 g of ice followed by 200 ml of
11 hexane. The organic layer was separated and the aqueous layer was
12 extracted with 2x50 ml of hexanes. The organic layers were combined
13 and washed successively with 30 ml of water and 2x30 ml of saturated
14 NaCl solution and then dried (MgSO₄). The solvent was removed in
15 vacuo and the residue purified by recrystallization from an ethyl
16 acetate and hexanes mixture to give the title compound as colorless
17 crystals.

18 ⁶⁷
19 ^N
20 PMR (CDCl₃): δ 1.91 (3H, s), 2.23 (3H, s), 5.73 (1H, broad s),
21 7.38-7.55 (5H, m).

20

CL₂

Example 20

21

CL

4,4-Dimethyl-6-bromo-2-oxo-1,2,3,4-tetrahydroquinoline

22

23 To 6.7 g (26.02 mmol) of molten N-(4-bromophenyl)3,3-
24 dimethylacrylamide (heated to 135°C) was added 4.15 g (31.09) of
25 aluminum chloride over 25 minutes. The reaction mixture was stirred
26 at 130°C for 16 hopurs and then treated with a further 1 g of
27 aluminum chloride. The reaction mixture was heated at 130°C for a
28 further 9 hours and then cooled to room temperature. The reaction
29 was then quenched by the slow addition of 100 ml of ice cold water
30 with slight warming of flask to facilitate mixing. The mixture was
31 extracted with 1x100 ml and 4x50 ml of ether. The organic extracts
32 were combined and washed with 25 ml of saturated NaCl solution and

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1 then dried (MgSO₄). The solvent was removed in vacuo and the
2 residue purified by flash chromatography (silica; 30% ethyl acetate in
3 hexanes) to give the title compound as a pale yellow solid.

4 PMR (CDCl₃): δ 1.37 (6H, s), 2.53 (2H, s), 6.85 (1H, d, J~8.4 Hz),
5 7.32 (1H, dd, J~8.4 Hz, 2.1 Hz), 7.43 (1H, d, J~2.1 Hz), 10.12 (1H, broad
6 s). ⁶⁷ ¹⁸ ¹⁸

7
8 *CLC*

Example 21

9 *CL* 4,4-Dimethyl-6-bromo-1,2,3,4-tetrahydroquinoline

10 *P* To 23.5 ml of 1.0 M (23.5 mmol) lithium aluminum hydride in
11 THF, heated to reflux under nitrogen, was added a solution of 4.95 g
12 (19.48 mmol) of 4,4-dimethyl-6-bromo-2-oxo-1,2,3,4-
13 tetrahydroquinoline in 50 ml of dry THF and 100 ml of dry diethyl
14 ether via a double-ended needle. The mixture was heated at reflux for
15 2 hours and then cooled to room temperature. The reaction mixture
16 was then quenched by the slow addition of 25 ml of water followed by
17 50 ml of 5% NaOH solution. The mixture was extracted with 2x25 ml of
18 ether, the organic extracts were combined and washed successively
19 with 25 ml each of water and saturated NaCl solution and then dried
20 (MgSO₄). The solvent was removed in vacuo and the residue purified
21 by flash chromatography (silica; 15% ethyl acetate in hexanes) to give
22 the title compound as a brown oil.

23 *P* PMR (CDCl₃): δ 1.27 (6H, s), 1.67-1.74 (2H, m), 3.23-3.32 (2H, m),
24 3.90 (1H, broad s), 6.33 (1H, d, J~8.4 Hz), 7.10 (1H, dd, J~8.4 Hz, 2.3 Hz),
25 7.25 (1H, d, J~2.3 Hz). ⁶⁷ ¹⁴ ¹⁴ ¹⁸ ¹⁸

26
27 *CLC*

Example 22

28 *CL* 4,4-Dimethyl-6-trimethylsilylethynyl-1,2,3,4-tetrahydroquinoline

29 *P* A solution of 1.608 g (6.7 mmol) of 4,4-dimethyl-6-bromo-
30 1,2,3,4-tetrahydroquinoline in 1.5 ml of triethylamine in a
31 heavy-walled tube was degassed under argon and then treated with

1 75 mg (0.39 mmol) of cuprous iodide and 150 mg (0.21 mmol) of
2 bis(triphenylphosphine) palladium (II) chloride. The mixture was
3 degassed again under argon, treated with 2.09 g (21.2 mmol) of
4 trimethylsilylacetylene and the tube was sealed. The mixture was
5 heated at 50°C for 48 hours. After cooling to room temperature
6 methylene chloride was added to the reaction mixture and the mixture
7 filtered. The filtrate was concentrated in vacuo and the residue
8 purified by flash chromatography (silica; 10% ethyl acetate in hexanes)
9 to give the title compound as a yellow oil.

10 ρ PMR (CDCl₃): δ 0.20 (9H, s), 1.20 (6H, s), 1.57-1.63 (2H, m),
11 3.16-3.25 (2H, m), 4.02 (1H, broad s), 6.24 (1H, d, $J=8.2$ Hz), 7.00 (1H,
12 dd, $J=8.2$ Hz, 1.8 Hz), 7.26 (1H, d, $J=1.8$ Hz).
13

14 $CL\frac{1}{2}$

Example 23

15 CL 4,4-Dimethyl-6-ethynyl-1,2,3,4-tetrahydroquinoline

16 ρ To a solution of 569 mg (2.21 mmol) of 4,4-dimethyl-6- ρ
17 trimethylsilylethynyl-1,2,3,4-tetrahydroquinoline in 3 ml of
18 isopropanol was added, under argon, 1 ml of 1N aqueous KOH solution.
19 The reaction mixture was stirred at room temperature for 36 hours
20 and the isopropanol was removed under vacuum. The residue was
21 extracted with ether and the ether extract was washed successively
22 with water and saturated NaCl solution and then dried (MgSO₄). The
23 solvent was removed in vacuo and the residue was purified by flash
24 chromatography (silica; 10% ethyl acetate in hexanes) to give the title
25 compound as a brown oil.

26 ρ PMR (CDCl₃): δ 1.26 (6H, s), 1.65-1.72 (2H, m), 2.96 (1H, s),
27 3.27-3.34 (2H, m), 6.34 (1H, d, $J=8.3$ Hz), 7.08 (1H, dd, $J=8.3$ Hz, 1.6 Hz),
28 7.33 (1H, d, $J=1.6$ Hz).
29

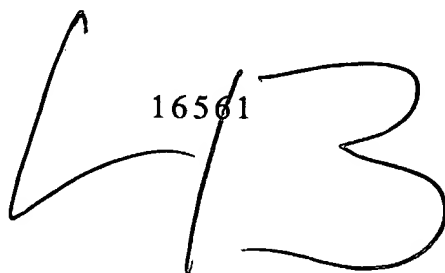
30 $CL\frac{1}{2}$

EXAMPLE 24

31 CL 6-(2-(4,4-dimethylchroman-6-yl)ethynyl)nicotinic acid

ρ The absolute ethanol used in this experiment was degassed by

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1 applying a vacuum while simultaneously bubbling nitrogen through it.
2 A solution of 101.1 mg (0.30 mmol) of ethyl
3 6-(2-(4,4-dimethylchroman-6-yl)ethynyl)-nicotinoate in 2 ml ethanol
4 was treated under argon with 0.7 ml of a 1.81 M (1.27 mmol) solution
5 of potassium hydroxide in ethanol and water. This mixture was stirred
6 at room temperature for 60 hours and then solvent removed in vacuo.
7 The residue was dissolved in 25 ml of water and extracted with 25 ml
8 of ether. The aqueous layer was acidified with glacial acetic acid and
9 extracted with 4x50ml of ether. Ether extracts were combined and
10 washed with water, then saturated NaCl and dried (MgSO₄). Solvent
11 was then removed in vacuo to give the title compound. PMR

67,14 12 ((CD₃)₂CO): δ 1.40 (6H, s) 1.88-1.92 (2H, m), 4.26-4.30 (2H, m), 6.82
18 13 (1H, d, J~8.7 Hz), 7.37 (1H, dd, J~7.6 Hz, 2.2 Hz), 7.62 (1H, M), 7.63 (1H,
L 14 d, J~8.7 Hz), 8.37 (1H, dd, J~7.6 Hz, 2.2 Hz), 9.27 (1H, d, J~2.2 Hz).

15 Proceeding in the same manner 6-(2-(4,4-dimethyl-
16 thiochroman-6-yl)ethynyl)nicotinic acid was prepared from ethyl
17 6-(2-(4,4-dimethylthiochroman-6-yl)-ethynyl)nicotinoate.

67 18 PMR (CDCl₃ (CD₃)₂ CO): δ 1.37 (6H, M), 1.99 (2H, m), 3.09 (2H,
18 19 m), 7.10 (1H, d, J~8.1 Hz), 7.28 (1H, dd J~8.1 Hz), 2.1 Hz), 7.64 (1H, dd,
L 20 J~7.8 Hz), 1.8 Hz), 7.65 (1H, d, J~7.8 Hz, 1.5 Hz), 9.24 (1H, m).

21 Proceeding in the same manner, the esters prepared as per the
22 preceding Examples may be converted to their corresponding acid.

23

24

CL₂ Example 25

CL 6-(2-(4,4-Dimethyl-thiochroman-6-yl)-ethynyl)-3-pyridylmethanol

26 p To 3.0 ml of 1 M lithium aluminum hydride (3.0 mmol) in THF,
31 27 cooled to -78°C, was added dropwise over 5 min a solution of 2.0 g (5.9
28 mmol) of ethyl 6-(2-(4,4-dimethylthiochroman-
29 6-yl)-ethynyl)nicotinate in 5 ml of THF. The reaction mixture was
31 30 stirred at -78°C for 40 min and then treated with 2 ml of water. The
31 mixture was warmed to room temperature and the organic layer was

1 separated. The aqueous layer was extracted with 3x10 ml of ether.
2 The organic extracts were combined and washed successively with
3 1x10 ml of dilute HCl, 3x10 ml of water and 1x15 ml of saturated NaCl
4 solution and then dried (MgSO₄). The solvent was removed in vacuo
5 and the residue purified by flash chromatography (silica; 50% ethyl
6 acetate in hexanes) to give the title compound as a pale yellow solid.
7 ^P PMR (CDCl₃): ⁰⁷δ 1.33 (6H, s), 1.91-1.98 (2H, m),
8 3.01-3.07 (2H, m), 4.75 (2H, s), 7.08 (1H, d, J~8.2 Hz), 7.23 (1H, dd,
9 J~8.2 Hz, 1.7 Hz), 7.46 (1H, d, J~7.9 Hz), 7.60 (1H, d, J~1.2 Hz), 7.71 (1H,
10 dd, J~7.9 Hz, 1.2 Hz), 8.51 (1H, broad s).
11

12 ^{CL}Example 26

13 ^{CL} 2-(4,4-dimethyl-thiochroman-6-yl)ethynyl)-5-bromopyridine

14 ^P A mixture of 6.36 g (31.5 mmol) of 4,4-dimethyl-6-ethynyl-
15 thiochroman, 7.46 g (31.5 mmol) of 2,5-dibromopyridine, 122 mg (0.64
16 mmol) of cuprous iodide, 224 mg (0.32 mmol) of
17 bis(triphenylphosphine) palladium (II) chloride and 70 ml of freshly
18 distilled triethylamine was degassed under nitrogen and stirred at
19 room temperature for 1 hour. The mixture was then treated with 180
20 ml of ether and 40 ml of water and the organic layer was separated.
21 The aqueous layer was extracted with ether, the organic layers were
22 combined and then washed with 2x40 ml of water, 2x40 ml of
23 saturated NaCl solution and then dried (K₂CO₃). The solvent was
24 removed in vacuo and the residue purified by flash chromatography
25 (silica; 5% ethyl acetate in hexanes) and recrystallization from ethyl
26 acetate and hexane to give the title compound as a pale brown solid.
27 ^P 6714 PMR (CDCl₃): ¹⁸δ 1.34 (6H, s), 1.94-1.98 (2H, m), 3.04-3.08 (2H, m),
28 7.08 (1H, d, J~8.4 Hz), 7.23 (1H, dd, J~8.4 Hz, 1.8 Hz), 7.38 (1H, J~8.4 Hz),
29 7.60 (1H, d, J~1.8 Hz), 7.78 (1H, dd, J~8.4, 2.3 Hz), 8.66 (1H, d, J~2.3 Hz).
30

31 ^{CL}Example 27

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Cl 2-(2-(4,4-dimethylthiochroman-6-yl)-ethynyl)-

5-pyridinecarboxaldehyde

To a cooled (-78°C) solution of 358 mg (1.0 mmol) of 2-(4,4-dimethylthiochroman-6-yl)ethynyl-5-bromopyridine in 5 ml of anhydrous ether was added slowly under nitrogen 1.3 ml of 1.7 M (2.21 mmol) tert-butyl lithium in pentane. The mixture was stirred at -78°C for 1 h and then treated with 95 mg (1.3 mmol) of anhydrous dimethylformamide. The mixture was stirred at -78°C for a further 0.5 hours, then warmed to 0°C and treated with 5 ml of saturated NH₄Cl solution followed by 5 ml of ether. The organic layer was separated and the aqueous layer was extracted with ether. The organic layers were combined, washed successively with water and saturated NaCl solution and then dried (MgSO₄). The solvent was then removed in vacuo and the residue purified by flash chromatography (silica; 15% ethyl acetate in hexanes) followed by high pressure liquid chromatography (Whatman M-9 Partisil 10/50 column, 15% ethyl acetate in hexanes) to give the title compound as a pale yellow solid.

¹H NMR (CDCl₃): δ 1.33 (6H, s), 1.93-1.97 (2H, m), 3.03-3.07 (2H, m), 7.08 (1H, d, J=8.2 Hz), 7.26 (1H, dd, J=8.2 Hz, 1.8 Hz), 7.63-7.65 (2H, m), 8.14 (2H, dd, J=8.0 Hz, 2.3 Hz), 9.05 (1H, d, J=2.3 Hz), 10.1 (1H, s).

EXAMPLE 28

Cl 2-[2-(4,4-Dimethylchroman-6-yl)ethynyl]-5-hydroxymethyl-
 7 pyridine 9

25 ρ A 250 ml 3-necked flask is fitted with a stirrer, a dropping
26 funnel, a nitrogen inlet and a thermometer. In the flask is placed a
27 solution of 379.5 mg (10 mmol) of lithium aluminum hydride in 30 ml
28 of dry diethyl ether. The solution is cooled to -65°C under nitrogen
29 and a solution of 3.2343 g (10 mmol) of ethyl
30 6-[2-(4,4-dimethylchroman-6-yl)ethyl]nicotinate in 15 ml of dry
31 ether is added dropwise at a rate such that the temperature does not

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31 1 exceed -60°C. The mixture is stirred at -30°C for 1 hour and the excess
2 hydride is then destroyed by the addition of 300 mg (3.4 mmol) of
3 ethyl acetate. The reaction mixture is then hydrolyzed by adding 3 ml
4 of saturated ammonium chloride solution and allowing the
5 temperature to rise to room temperature. The mixture is then filtered
6 and the residue washed with ether. The ether layer is then washed
7 with saturated sodium chloride solution, dried (MgSO₄) and then
8 concentrated in vacuo. The residue is purified by chromatography
9 followed by recrystallization to give the title compound.

10 By the same process, acids or esters of this invention may be
11 converted to their corresponding primary alcohol.

12
13 CL₂
14 CL 2-[2-(4,4-Dimethylchroman-6-yl)ethynyl]-5-acetoxymethyl-
15 pyridine

16 p A solution of 2.81 g (10 mmol) of 2-[2-(4,4-dimethylchroman-6-yl)ethynyl]-5-hydroxymethylpyridine, 600 mg (10 mmol) of glacial
17 acetic acid, 2.06 g (10 mmol) of dicyclohexylcarbodiimide and 460 mg
18 (3.765 mmol) of 4-dimethylaminopyridine in 150 ml methylene
19 chloride is stirred at room temperature for 48 hours. The reaction
20 mixture is then filtered and the residue washed with 50 ml of
21 methylene chloride. The filtrate is then concentrated in vacuo and the
22 residue is purified by chromatography followed by recrystallization to
23 give the title compound.

24
25 Proceeding in the same manner, other alcohols of this invention
26 may be esterified.

27
28 CL₂
29 CL 2-(2-(4,4-Dimethylchroman-6-yl)ethynyl)-
30 pyridine-5-carboxaldehyde

31 p A solution of 1.396 g (11 mmol) of freshly distilled oxalyl

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1 chloride in 25 ml of methylene chloride is placed in a 4-necked flask
2 equipped with a stirrer, a thermometer and two pressure- equalizing
3 addition funnels fitted with drying tubes. The solution is cooled to
4 -60°C and then treated dropwise with a solution of 1.875 g (24 mmol)
5 of dimethyl sulfoxide (distilled from calcium hydride) in 5 ml of
6 methylene chloride over a five minute period. The reaction mixture is
7 then stirred at -60°C for an additional 10 minutes. A solution of 2.82 g
8 (10 mmol) of 2-[2-(4,4-dimethylchroman-6-yl)ethynyl]-5-hydromym-
9 ethylpyridine in 10 ml of methylene chloride is then added to the
10 reaction mixture over a period of 5 minutes. The mixture is stirred for
11 a further 15 minutes and is then treated with 5.06 g (50 mmol) of
12 triethylamine. The cooling bath is then removed and the mixture is
13 allowed to warm to room temperature. Thirty ml of water is then
14 added to the mixture and stirring is continued for a further 10
15 minutes. The organic layer is then separated and the aqueous layer is
16 extracted with 20 ml of methylene chloride. The organic layers are
17 then combined and washed successively with dilute HCl, water and
18 dilute Na₂CO₃ solution and then dried (MgSO₄). The solution is then
19 filtered and concentrated in vacuo and the residue is purified by
20 chromatography followed by recrystallization to give the title
21 compound.

22 Primary alcohols of this invention may be oxidized to their
23 corresponding aldehyde by this method.

24

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CL₂

Example 31

CL 2-(2-(4,4-Dimethylchroman-6-yl)ethynyl)-5-(
(1-hydroxypropyl)pyridine

Four ml of a 3 M (12 mmol) solution of ethylmagnesium bromide
in ether is placed in a 3-necked flask fitted with a mechanical stirrer, a
reflux condenser protected by a drying tube and a pressure-equalizing
dropping funnel protected by a drying tube. The flask is cooled in an

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1 ice bath and a solution of 2.8 g (10 mmol) of
2 2-(2-(4,4-Dimethylchroman-6-yl) ethynyl)-
3 pyridine-5-carboxaldehyde in 10 ml of dry ether is added slowly with
4 vigorous stirring. The cooling bath is then removed and the mixture
5 heated at reflux for 3 hours. The mixture is then cooled in an ice-salt
6 bath and 5 ml of saturated ammonium chloride solution added. The
7 mixture is stirred for a further 1 hour and then filtered and the
8 residue washed with two 10 ml portions of ether. The ether solution is
9 then separated, dried (MgSO₄) and the ether removed in vacuo. The
10 residue is then purified by chromatography followed by
11 recrystallization to give the title compound.

12 Using the same procedure any of the other aldehydes of this
13 invention can be converted to a secondary alcohol.

14 Such secondary alcohols may be converted to their corresponding
15 ketone using the procedure recited in Example 15.

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CL²

Example 32

CL 2-(2-(4,4-Dimethylchroman-6-yl)ethynyl)-5-
dimethoxymethylpyridine

P A round-bottomed flask is fitted with a Dean-Stark apparatus
under a reflux condenser protected by a drying tube. A mixture of
3.35 g (12 mmol) of 2-(4,4-dimethylchroman-6-yl)ethynyl-pyridine-
5-carboxaldehyde, 4.80 mg (15 mmol) of anhydrous methanol, 2 mg of
P-toluenesulfonic acid monohydrate and 10 ml of anhydrous benzene
is placed in the flask and the mixture heated at reflux under nitrogen
until close to the theoretical amount of water is collected in the
Dean-Stark trap. The reaction mixture is cooled to room temperature
and extracted successively with 5 ml of 10% sodium hydroxide solution
and two 5 ml portions of water and then dried (MgSO₄). The solution
is then filtered and the solvent removed in vacuo. The residue is
purified by chromatography and then recrystallization to give the title

1 compound.

2 In a similar manner, any aldehyde or ketone of this invention
3 may be converted to an acetal or a ketal.

4

5 *cl₂c* Example 33

6 *p* Preferably, these compounds may be administered topically
7 using various formulations. Such formulation may be as follows:

8
9 Ingredient Weight/Percent

10
Tosoox
11 Solution

12	Retinoid	0.1
13	BHT 0.1	
14	Alcohol USP	58.0
15	Polyethylene Glycol 400 NF	41.8

16

17 Gel

18	Retinoid	0.1
19	BHT 0.1	
20	Alcohol USP	97.8
21	Hydroxypropyl Cellulose	2.0

22